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Population Dynamics in Response to Fire in *Quercus laevis - Pinus palustris* Barrens and Related Communities in Southeast Virginia

Allen E. Plocher
Old Dominion University

POPULATION DYNAMICS IN RESPONSE TO FIRE IN
Quercus laevis - Pinus palustris BARRENS AND RELATED
COMMUNITIES IN SOUTHEAST VIRGINIA

by

Allen E. Plocher
A.A.S., June 1977, D. S. Lancaster Community College
B.S., December 1980, Old Dominion University
M.S.F., May 1984, West Virginia University

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Approved by:

Gerald F. Levy, ~~Ph.D.~~ (Director)

Frank P. Day, Jr., Ph.D.

Joseph H. Rule, Ph.D.

ABSTRACT

Plant Population Dynamics in Response to Fire in *Q. laevis* - *P. palustris* Barrens and Related Communities in Southeast Virginia

Allen E. Plocher
Old Dominion University, 1993
Director: Gerald F. Levy, Ph.D.

Permanent plots in the Zuni Pine Barrens (Isle of Wight Co., Virginia) were sampled in order to: quantify plant population dynamics in response to fire, compare these dynamics among different moisture regimes, compare the effect of mechanical understory removal to that of fire on tree seedling and herbaceous dynamics, and determine the effect of dense lichen (*Cladonia spp.*) coverage on pine seedling establishment and survival. Fire resulted in 40% aboveground mortality in the overstory, 80% in the sapling / large shrub layer, and nearly 100% in the understory, followed by a 3.3 to 10.6 fold increase in understory density. Regeneration was predominantly by vegetative means and shrub species accounted for greater than 90% of the post-fire density and 80% of the increase in density. In the wetter areas, tree and herbaceous species made up a larger percentage of post-fire understory density than was the case in drier areas, and species diversity was greater. In drier areas, the same species which

dominated the understory before the fire continued to do so afterward, and these same species increased in number significantly more than other species. In the wetter areas, the majority of pre-fire dominant understory species were no longer important components of the communities after the fire, and these species either failed to increase significantly or even decreased in number. Several species that were not important components of the communities before the fire increased significantly more than others and were among the dominant post-fire understory species. In drier areas, all significant changes in density occurred in the first year following the fire, while in wetter areas, significant changes occurred in the second year as well. Burning differed from mechanical clearing of the understory in that tree seedling species exhibited greater densities and increases in density. Burned areas did not differ from mechanically cleared areas in herbaceous density or dynamics, but differences in herbaceous species composition were noted. Dense lichen patches did not differ from areas devoid of lichens with respect to pine seedling mortality. Pine seedling density, however, was significantly greater in lichen patches.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

In the presettlement southeastern United States, fire dependent communities, such as those dominated by *Pinus palustris* (longleaf pine), covered large areas. It is only recently that the detrimental effect of fire suppression on these communities has been recognized. Fire suppression, conversion to agricultural use and conventional forestry practices have reduced the original extent of longleaf pine communities from 24 million ha to 2 million ha (Dennington and Farrar, 1983). Currently, considerable effort is being expended to reestablish fire regimes in order to benefit rare species and maintain these unique and threatened ecosystems (Frost et al., 1986; Frost and Musselman, 1987).

The Zuni Pine Barrens in Isle of Wight County, Virginia, locally well known and described by Fernald in the 1930's, is a fire dependent community with an open, *P. palustris* (longleaf pine) - *Quercus laevis* (turkey oak) - *P. taeda* (loblolly pine) overstory, a dense understory of low, ericaceous shrubs and frequent openings dominated by herbaceous species, lichens and mosses (Frost and Musselman, 1987). The area is unique and important for five reasons: (1) only a very few pine barrens remain in the state, (2) the Zuni Barrens may contain the state's only reproducing population of *P. palustris*, (3) some 15 threatened plant species (species of special concern) occur in and around these barrens, (4) the area is the extreme northern limit for at least six plant species of the southern pine savannahs: *P. palustris, Q. laevis, Polygonella polygama, Aristida virgata, Carphephorus bellidifolius* and *C. tomentosus,* and (5) the area contains many species disjunct from populations to the north and south and is perhaps a community type distinct from both southern (North Carolina) and northern (New Jersey) pine barrens.

A 129.1 ha (319 ac) tract of land containing the majority of the Zuni Pine Barrens along with adjacent, wetter habitats was donated to the Nature Conservancy and in turn Old Dominion University by Union - Camp Corporation in 1985 and is now called the Blackwater Ecologic Preserve. The primary purposes of the preserve are to protect and maintain the unique communities present and to provide a site for ongoing ecological research.

Very little work has been done on plant community dynamics in pine barrens. In the New Jersey Pine Barrens, studies by Boerner (1981) and Buell and Cantlon (1953) have examined shrub community dynamics in response to fire. Olsson (1979) studied phytosociology and Little (1979) studied succession in several New Jersey barrens communities. They related their findings to fire in a general way. Platt et al. (1988) examined the population biology of *P. palustris* and the flowering dynamics of herbaceous and shrub species in response to fire in Georgia and Florida pine savannahs, respectively. Grelen (1975) reported the effects of various fire regimes on understory composition in a Louisiana *P. palustris* stand. Waldrop et al. (1987) conducted a similar study in South Carolina *P. taeda* stands. In fact, very few synecological studies have integrated the study of individuals, populations and communities (Sarukhan et al., 1985; Huston and Smith, 1987). Grubb (1985) laments the general scarcity of plant community demographic studies utilizing permanent plots.

The present study had several main goals. The first was to examine the effect of fire on plant demography, population dynamics (mortality and regeneration), shifts in dominance and species composition on two adjacent parcels, each containing xeric longleaf pine barrens and wetter communities and to compare these fire effects between the barrens and adjacent mesic and hydric forests. The second was to examine more open, typical barrens sites within the pine barrens ecosystem to determine the dynamics of herbaceous and tree regeneration following fire, to observe and quantify the effect of overstory removal on these dynamics and to compare fire related understory effects to mechanical understory removal. The relationships between post fire understory dynamics and edaphic factors such as available soil moisture and nutrient concentration were also investigated. Third, due to the apparent high frequency of large, lichen dominated patches in openings, a study was conducted to determine the effect of lichens on pine seedling establishment and mortality.

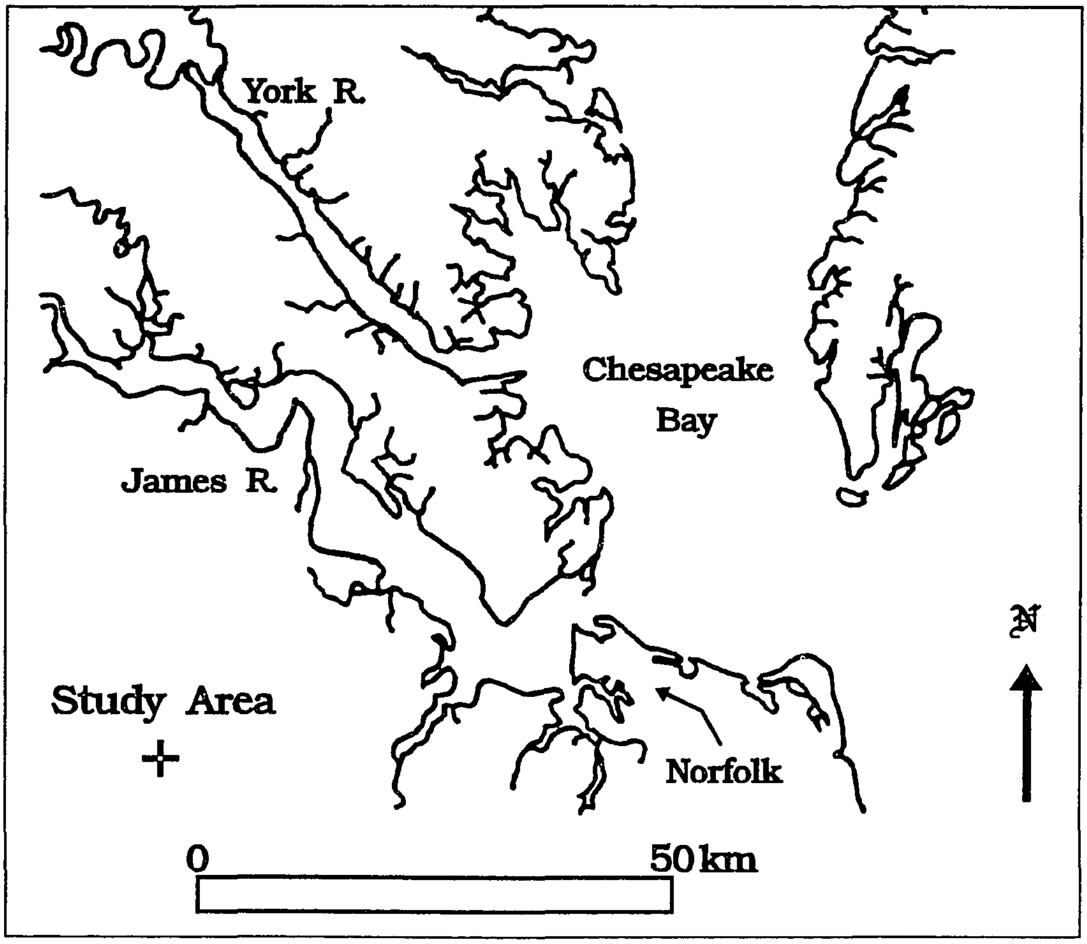
STUDY AREA

The study area is located in Isle of Wight County, Virginia; 0.7 km east of the Blackwater River (36°49' N, 76°51' W) and 7.3 km southwest of the town of Zuni (figure 1).

The first area burned is 21.1 ha and contains 7.5 ha of xeric, *P. palustris* - *Q. laevis* barrens (Barrens 1) surrounding 9.1 ha of mesic, *P. serotina* - *P. taeda* forest (Mesic Area 1) with 4.5 ha of *Acer rubrum* - *P. serotina* swamp (Swamp) in the center of the tract. Burn Area 1 was burned on February 26, 1986 and again on July 29, 1987.

The second area burned is 11.6 ha, borders the northern edge of BA1, and contains 4.1 ha of xeric *P. serotina* - *P. palustris* - *Q. laevis* barrens located at the eastern end of the parcel with an additional 0.7 ha at the western end (Barrens 2), and 6.8 ha of mesic *P. taeda* - *P.serotina* forest located in the central portion of the tract (Mesic Area 2). Burn Area 2 was burned on February 28, 1988. An unburned parcel, adjacent to the eastern edge of Burn Area 2, is designated as Control and consists of 2.4 ha of xeric *P. taeda* - *P. palustris* - *Q. laevis* barrens. All areas were clear-cut and burned between 1955 and 1957 (Union-Camp Corp. stand records) and regeneration was natural except for the southernmost 1/4 of the pine barrens in Burn Area 1, which were planted with Louisiana stock *P. palustris*. The forests

Figure 1. Study Area location in southeast Virginia.


York R.
Chesapeake
Bay
James R.
Study Area
Norfolk
N
0
50km

were found to be 32 years oldand even-aged (σ = 3.9, n = 201) at the time of the study.The wetter areas, however, had a scattering of larger trees about 50 to 60 years old.

The topographic relief is low and the entire study area, except for the Swamp, is overlain with Pleistocene sands of the Windsor Formation. The soils are Leon - Chipley sands, Typic Quartzipsamments, to a depth of more than 153 cm. Certain areas within the barrens of both burn areas contain a spodic horizon at 58 to 76 cm. The soil is highly acid (pH ranges from 4.1 to 4.9) and droughty but possesses a seasonably high water table. The Swamp has an organic peat soil, a Typic Medisaprist, to a depth of 61 cm (Isle of Wight County Soil Survey, 1987; Frost and Musselman, 1987).

The mean annual precipitation from 1951 to 1980 was 122.3 cm at Holland, Virginia (36°41' N, 76°47' W). The mean annual precipitation from 1985 to 1989 was 122.1 cm (σ = 26.06). Mean annual temperature from 1985 to 1989 was 14.9° C (58.8° F) (NOAA, 1990).

METHODS

Study 1: Comparison of Vegetation Dynamics Between Communities with Different Moisture Regimes

Vegetation was sampled using stratified regular sampling. Parallel transects were established perpendicular to the long axes of the parcels at intervals of 100.6 m for Burn Area 1 and 80.5 m for Burn Area 2 (BA2 is smaller in size and an effort was made to maximize the sample size without drastically altering the sample design). Plots were established at sample points 80.5 m apart with the first plot 40.3 m from the beginning of each transect. Overstory species ($\geq$ 10 cm DBH) and saplings and large shrubs (< 10 cm and > 1.25 cm DBH) were sampled in 100 m^2 circular plots centered at the sample points. Understory species including herbaceous plants, low shrubs, vines and tree regeneration $\leq$ 1 m tall were sampled in 1 m^2 quadrats parallel to the transect bearing, with the sample point at the upper right corner. Individuals in the 100 m^2 plots were separated into sapling and overstory categories in the initial sample and remained so throughout the study so that recruitment into the overstory category by diameter growth would not confuse the demographic study. The understory, sapling / large shrub, and overstory layers were sampled as numbers of individuals (stems) by species per plot. In understory samples, trees, shrubs and vines were categorized as seedlings or vegetative sprouts. Understory and sapling / large shrub importance values (IV) were calculated as (relative density + relative frequency)/2. Overstory dominance (basal area) by species was determined using the Bitterlich (prism) method at the sample points. Importance values for overstory species were calculated as (relative density + relative frequency + relative dominance)/3. In each burn area, plots were separated into community types. In Burn Area 1, 10 pine barrens plots, 12 mesic forest plots and 6 swamp plots were sampled. In Burn Area 2, 6 pine barrens plots and 9 mesic forest plots were sampled. In each burn area, plots were sampled annually at the end of the growing season (August and September). Almost all species occurring in the study area are perennial and no spring ephemerals are known to be present. In Burn Area 1, plots were sampled in 1985 (before burning), 1986, 1988 and 1989 (in 1987, the late July burn resulted in almost complete removal of understory vegetation before the sampling period). In Burn Area 2, plots were sampled in 1986 (before burning), 1988 and 1989. In addition, pine barren understory plots in both burn areas were sampled in 1991.

Study 2: Comparison of Understory Vegetation Dynamics Between Burned and Mechanically Cleared Treatments

Understory Population Dynamics

In Burn Area 1, within one contiguous 3.6 ha section of pine barren and in the 2.4 ha control area, 10 circular plots, 500 m^2 (dia. = 25.2 m) were established such as to be as similar as possible to each other in species composition, vegetative structure and topography. In addition, the plots contained features characteristically associated with barrens (bare sand and sparsely vegetated openings dominated by herbaceous species, lichens and mosses) and likely to be condusive to herbaceous and tree regeneration. Two plots were randomly assigned to each of five treatments: burned, not logged; burned and logged; mechanically cleared and logged; mechanically cleared, not logged; and control. Burning, however, could not be randomly assigned. The 500 m^2 size was chosen so that logged plots would have major portions receiving full sun and free from tree root competition, and because, in *P. palustris* barrens, tree regeneration was found to occur in small clumps with a mean area of less than 1000 m^2 (Platt et al., 1988). Each plot was divided into twelve wedge shaped sections which were subdivided into inner and outer portions of equal area; making 24, 20.8 m^2 subplots. Numbers of individuals (stems) of tree and herbaceous regeneration were tallied by species for each subplot late in the growing season (July and August) in 1988, 1989 and 1991.

Seed Production and Sexual Reproduction

In addition to examining changes in vegetational composition, factors related to sexual reproduction were also studied. (1) For each plot, in 1988 and 1989, total numbers of fruits per unit area were tallied by species for shrubs and herbaceous plants. (2) The soil seed bank was examined: for each plot, a 0.14 m^2 section of mineral soil 7.0 cm thick was carefully excavated and removed in a plastic seed flat in November, 1988. The organic A_0 horizon was discarded. The flats were incubated in the Old Dominion University greenhouse, watered regularly and observed for 12 months. The soil was turned over every two months. Germinated seedlings were counted and mapped weekly for each plot and, if possible, identified to species. (3) Overstory tree seed production per unit area was determined. Adjacent to each of the 10 plots, a 1 m^2 cotton cheesecloth seed trap was constructed. Monthly, for 33 months from October 1987 until June 1990, seeds were counted and identified to species. For each species, seedfall was calculated as seeds per m^2 per year.

Edaphic Factors

Edaphic factors were monitered for each plot. Percent available soil moisture was measured monthly for 26 months, from June 1988 until August 1990, using a Bouyoukos gypsum block system. This system determines moisture as a function of electrical resistance. To reduce sampling bias, measurements were taken on the last day of the month. In September 1988, litter depth was measured at four randomly located points in each plot. Four, 25 g (ca.) soil samples were collected at a depth of 10 cm from randomly located points in each plot and then commingled. For percent organic carbon, and exchangeable acidity, Al^{+3} and H^+, samples were collected in October 1989 and refrigerated at 4.4° C until analysis (less than 30 days). Percent organic carbon was determined using the Titration method (Gaudette et al., 1974). Exchangeable acidity, Al^{+3} and H^+, in meq. per 100 g, were determined using the Potassium Chloride Titration Method (Thomas, 1982). For each plot, pH and concentrations of macronutrients (NO_3-N, phosphorus, potassium, calcium and magnesium) and the micronutrient manganese were determined from samples collected in the summers of 1988 and 1989, and in the winter of 1989. Analysis was conducted by the Soil Testing Laboratory at Virginia Polytechnic Institute and State Univ., Blacksburg, Virginia. A pH meter was used for soil pH determination using 1:1 ratios of soil and deionized water. Phosphorus, potassium, calcium, magnesium and manganese were analyzed by inductively coupled plasma spectrophotometer using an extracting solution of .05 N HCL in .025 N NH_2SO_4. Nitrate nitrogen was analyzed using an ionalyzer with a nitrate specific ion electrode and an extracting solution of .02 N $CuSO_4$ (Donohue and Gettier, 1988).

Study 3: Lichen Study

In the control area, two, 2 m^2 plots were established for each of three treatments; 100 % lichen covered, natural bare sand, and lichen removed. All plots were located within a 100 m^2 area. In each plot, seven, 1-0 *P. palustris* seedlings of local origin were planted in March 1990. Seedling mortality by plot was monitored for 20 months. The 500 m^2 plots located in the control area of Study 2 contain large open areas (> 20 m^2) covered with lichens (*Cladonia* spp.). Relatively large numbers of *P. taeda* seedlings were established in 1989. Subplots within plots were assigned to one of two treatments; lichen covered or lichen absent. For each treatment, the number of *P. taeda* seedlings per subplot was determined (for the lichen covered treatment only those seedlings occurring in lichens were counted). Also, for each treatment, the difference between number of seedlings per subplot between 1989 and 1991 (mortality) was determined.

STATISTICAL METHODS

Statistical analysis was carried out using SAS version 606. Paired and unpaired T-tests were conducted using the Means procedure and Ttest procedure, respectively. Anovas were conducted using the GLM procedure. Multivariate based repeated measures Anovas were carried out using the Repeated statement and Manovas were carried out using the Manova statement. For univariate Anovas, Tukey's mean separation technique was used. For multivariate analyses, the Wilk's Lambda test statistic was used. Canononical Discriminant Analyses was done using the Candisc procedure.

Analysis of vegetation dynamics was conducted on the most abundant or dominant species. Since there were as many as 42 understory species present in some communities, including all species would have resulted in too many variables for statistical analysis. In addition, rare species occur in too few samples (replicates) for meaningful interpretation. Therefore, an effort was made to apply a species elimination process equally across all communities and layers. In each community and layer, approximately the upper 40% of the species present in order of decreasing dominance were included in the analysis. Only those species with three or more replicates per site were included and elimination was based on frequency thresholds in order to remove species bias.

Since the goals of this study were to examine fire induced vegetational dynamics as they relate to individuals and populations, statistical methods were used which took into account repeated measures of the same plots (and therefore individuals) over time.

For T-tests on vegetation dynamics and Anovas on edaphic factors, alpha levels of .05 were used to decide statistical significance. For Anovas and Discriminant Analyses on differences between species, alpha levels of .005 were used.

Study 1

Fire induced mortalities in the overstories and sapling / large shrub layers were analysed. For the dominant species, paired one-tailed T-tests were conducted to determine which species decreased in abundance due to fire. For Burn Area 1, the variates analyzed were Diff86 (the difference in number per plot between prefire samples (1985) and 1986 samples) and Diff89 (the difference in number between 1986 and 1989). For Burn Area 2, the variates analyzed were Diff88 and Diff89. In order to determine whether there was a difference between species in change in number over time, one-way Anovas were conducted using species as treatments and Diff86, Diff88 and

Diff89 as variates (independent variables).

In the understory, species' fire related population dynamics were studied. Because these population dynamics are complex processes involving regeneration and subsequent mortality and cooccurring species affect one another resulting in possible interaction and lack of independence, and because a number of subtly different questions were addressed, several statistical analyses were conducted.

For the dominant species, two-tailed paired T-tests were conducted to determine whether changes in number between years occurred. The variates were Diff86, Diff88, Diff89 and, in Barrens 1 and Barrens 2, Diff91. A multivariate based repeated measures Anova was used to determine whether there were differences in numbers of individuals per plot due to time, and which species differed from the mean in change over time. In this analysis, time is treated in a multivariate sense in order to overcome the possible lack of independence between subsequent years.

In order to overcome possible lack of independence between species, Canononical Discriminant Analyses were conducted in which numbers of individuals by species were used as dependent variables and times (years) were independent variables. This very conservative technique determines whether separation between years exists and whether this separation can be described in terms of some combination of species and their densities. Contrast techniques within the multivariate based repeated measures Anovas were used to determine which species to include in the canononical coefficients.

In order to examine the dynamics of the broad categories; trees, shrubs and herbaceous plants, paired, two-tailed T-tests were conducted to determine whether differences in number per plot existed between years.

For each species that regenerated by both sexual and vegetative means, an unpaired, two-tailed T-test was conducted to determine whether a difference existed between amount of sexual (seedling) and vegetative (sprout) regeneration.

<u>Study 2</u>

A nested Anova and a one-way Anova by plot were conducted on percent available soil moisture. For each soil nutrient, a one-way Anova was conducted on nutrient concentration (ppm) to determine if concentrations differed between summer and winter. For each soil nutrient, nested Anovas by treatment (five) and plot within treatment and one-way Anovas by plot were carried out on nutrient concentration.

Herbaceous and tree regeneration dynamics between 1988 (one year after disturbance) and 1989, and between 1989 and 1991, were studied. For the dominant species in each of the five treatments, paired two-tailed T-tests were conducted to determine whether changes in number per plot between years occurred. The variates were Diff89 and Diff91. Multivariate based repeated measures Anovas were conducted to determine whether differences in numbers of individuals (stems) per plot exist due to time and to determine which species differ from the mean in change over time. Nested Anovas by species and plot within species were carried out in order to determine which species differed from each other in change in number over time and to determine if variation between plots existed. Canononical Discriminant Analyses were conducted to determine whether separation between years existed and which species and their densities contributed to the separation.

Using only those species which were present in all treatments, a doubly multivariate repeated measures Anova was conducted to determine: (1) whether differences between treatments, in change in number by species, existed and which treatments differed from the mean, (2) which species differed between treatments, (3) whether differences in number of individuals per plot occurred due to time and which species differed from the mean in change over time, and (4) whether an interaction between treatment and time occurred.

For species regenerating by both sexual and vegetative means, unpaired, two-tailed T-tests were carried out to determine whether differences existed between amounts of seedling and sprout regeneration.

Study 3

A one-way Anova by the treatments; 100% lichen covered, natural bare sand, and lichen removed was conducted on the variate Diff1990-1989 (seedling mortality) to determine whether differences existed between treatments in amount of mortality to planted seedlings. A nested Anova and a one-way Anova were conducted on the variate natural seedling density, to determine whether seedling density differed between treatments. A one-way Anova by the treatments lichen covered and lichen absent, was carried out on the variate Diff1989-1991 (natural seedling mortality) to determine whether differences in natural mortality existed between treatments.

RESULTS

Study 1

The effect of fire on survivorship was such that, on mineral soil, overstory mortality ranged from 19.0% to 46.7%. In the sapling/large shrub layer, the effect was more severe with mortality ranging from 73.9% to 90.7%. The herb/ low shrub layer in all cases exhibited nearly 100% loss of aboveground biomass. Perhaps the most dramatic effect was seen in the Swamp, where a belowground fire consumed 60 cm of histosol over about 25% of the total area, creating a 0.5 ha pond and causing 63.8% overstory mortality.

With the exception of Mesic Area 2, which had a high percent mortality in the second year, almost all of the mortality occurred the first year after the burn in all vegetation layers. Detailed results are reported in Apppendix 1.

Overstory and Sapling Layers

In Barrens 1, analyses of variance showed that in both the overstory and sapling layers *Q. laevis* mortality differed from that of other species and its IV dropped from highest to among the lowest (overstory; 28.3 to 3.9, sapling; 25.6 to 7.9). *P. palustris* had the lowest mortality (10.3%, 66.2%) and increased to highest IV's (43.7, 30.3) in both layers (Table 1).

As in Barrens 1, *Q. laevis* had a very high mortality in both the overstory and sapling layers of Barrens 2. *P. palustris* experienced fairly low mortality in the overstory but was lost from the sapling layer sample, while *P. taeda*, a less fire resistant species, showed no mortality in either layer. The sample size in Barrens 2 was rather small (six plots), and this may explain why the statistical analyses of overstory and sapling layer mortality were, for the most part, not significant (Table 1).

In Mesic Area 1, results of an Anova showed that *P. serotina* decreased more than other species in the overstory. However, *P. serotina* and *P. taeda* remained strong dominants after the fire (IV's = 47.3, 20.7). In the sapling/large shrub layer of Mesic Area 1, an Anova showed that *V. corymbosum* and *A. canadensis* decreased more than other

Table 1. Study 1. Burn Areas 1 and 2. Overstory, Sapling and Understory species exhibiting statistically significant population dynamics. * = population increases.

Overstory	Sapling	Understory	Overstory	Sapling	Understory	Overstory	Sapling	Understory
Burn Area 1								
Barrens			Mesic			Swamp		
Q.laevis	*Q.laevis*	*G.baccata**	*P.serotina*	*V.corymbosum*	*A.rubrum**	*A.rubrum*	*V.corymbosum*	*A.rubrum**
		*K.angustifolia**		*P.serotina*	*G.frondosa**		*M.virginiana*	
				M.virginiana	*P.aquilinum**		*A.canadensis*	
				P.taeda				
				A.rubrum				
				A.canadensis				
Burn Area 2								
Barrens			Mesic					
	Q.laevis		*P.taeda*	*M.virginiana*	*R.nudiflorum**			
	P.serotina		*A.rubrum*	*O.arboreum*				
				P.taeda				
				V.corymbosum				
				A.rubrum				
				I.opaca				

species. While *V. corymbosum* remained the dominant sapling layer species, *A. canadensis* ceased to be a significant component of the stand (Table 1).

Mesic Area 2 was similar to Mesic Area 1 in that *P. taeda* and *P. serotina* strongly dominated the overstory (IV's = 26.8, 21.9) while the hardwoods *A. rubrum, N. sylvatica, Q. nigra* and *L. styraciflua* were present at much lower values (IV's = 9.6, 7.3, 8.1, and 6.1, respectively). *V. corymbosum* dominated the sapling/large shrub layer (IV = 13.9), although to a lesser degree, and the hardwoods *O. arboreum, A. rubrum, N. sylvatica* and *L. styraciflua* (IV's = 11.5, 10.5, 10.8 and 7.1, respectively) were the dominant sapling trees while *P. taeda* and *P. serotina* were less numerous (Table 1).

Mesic Area 2 exhibited unique overstory dynamics following fire. Overstory mortality was lower and was dispersed over the first and second years instead of occurring predominantly in the first year. All *P. serotina* mortality occurred in the first year while all *A. rubrum* mortality occurred in the second year. No species changed in relative importance value. Results of an Anova showed that *A. rubrum* mortality in the second year differed from *P. serotina, N. sylvatica* and *L. styraciflua*. In the sapling layer as well, a considerable part of the mortality occurred in the second year. *V. corymbosum* suffered extensive mortality (80.5%), dropped considerably in IV (from 13.9 to 5.5) and a T-test showed that it decreased significantly. As in Mesic Area 1, *A. rubrum* and *N. sylvatica* increased in importance (10.5 to 15.4 and 10.8 to 18.7, respectively) and, in this case, *P. taeda* and *P. serotina* were completely lost from the sapling sample (Table 1).

The Swamp in BA1 exhibited dynamics following fire very different from all other areas. Overstory mortality was much higher (63.8% compared to 46.8% in Mesic Area 1). Due to the combustion of the organic soil, shallow rooted species (especially *A. rubrum*) lost support for their roots and were felled. The more deeply rooted *P. serotina* and *P. taeda* suffered lower mortality. Mortality predominantly occurred the first year after the burn. In the sapling/large shrub layer, *V. corymbosum, A. canadensis* and *A. rubrum* suffered heavy mortality (90.9%, 86.4% and 82.8%, respectively), but remained dominant and, as in Mesic Area 2, *P. taeda* and *P. serotina* were lost from the sapling layer. T-tests showed that, in the overstory *A. rubrum* decreased and, in the large shrub layer, *V. corymbosum, A. canadensis* and *M. virginiana* decreased. An Anova showed no significant differences, perhaps because of the small sample size (six plots) (Table 1).

Understory

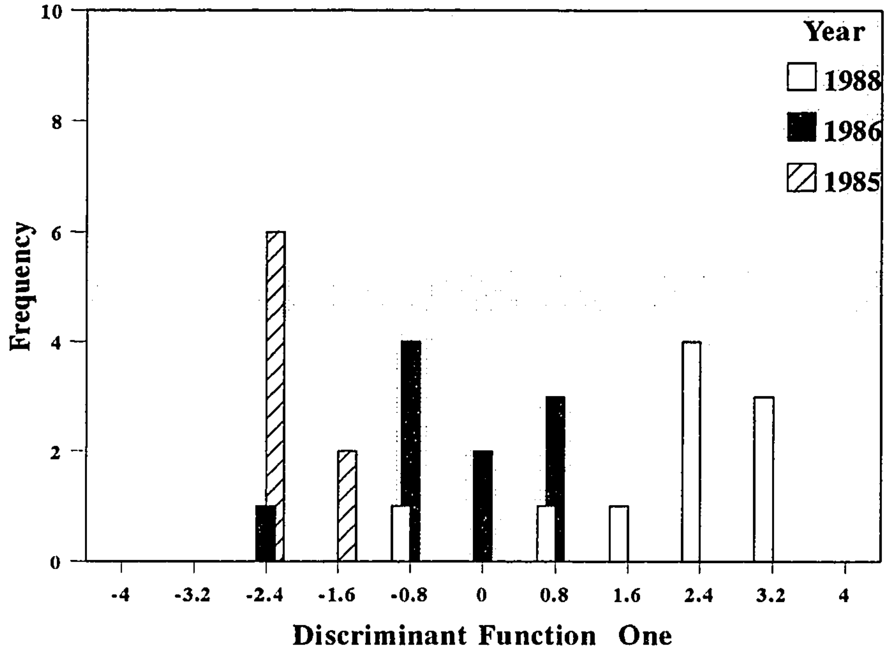
Following the nearly total initial loss of above-ground biomass, the overall effects on the understory were those of dramatic increases in densities of individuals and numbers of species. In the five areas sampled, density exhibited a 3.3 to 10.6 fold increase. The effect on species diversity was a doubling on Barrens and Mesic Areas and a four-fold increase in the Swamp. The majority of the dominant species and those increasing in density were shrubs. In all areas, density increased in the first year after the burn. In Mesic Area 1 and in the Swamp there were also increases in the second year.

In Barrens 1, a repeated measures Anova showed that the increases in numbers of individuals occurred in the first year after the burn. A Canononical Discriminant Analysis demonstrated that the important differences between species in population dynamics occurred between pre-fire and the first year post fire, and not between subsequent years. *G. baccata* and *K. angustifolia* strongly dominated the understory before the fire. A repeated measures Anova showed that these species exhibited greater than average increases. *P. aquilinum* sharply decreased in IV following the fire (9.3 to 3.8). Paired t-tests showed that only shrubs increased as a whole following the fire (Table 1, figures 2 and 3).

In Barrens 2, the understory was dominated by species noticeably lower in height than in Barrens 1. Although *G. baccata* and *K. angustifolia* were among the dominant species (IV's = 10.6, 14.7), the most dominant were *G. procumbens* and

Figure 2. Separation between years by Canononical Discriminant Analysis. A. Barrens 1, B. Mesic Area 1.

A.


Year
1988
1986
1985
Frequency
10
8
6
4
2
0
-4
-3.2
-2.4
-1.6
-0.8
0
0.8
1.6
2.4
3.2
4
Discriminant Function One

B.

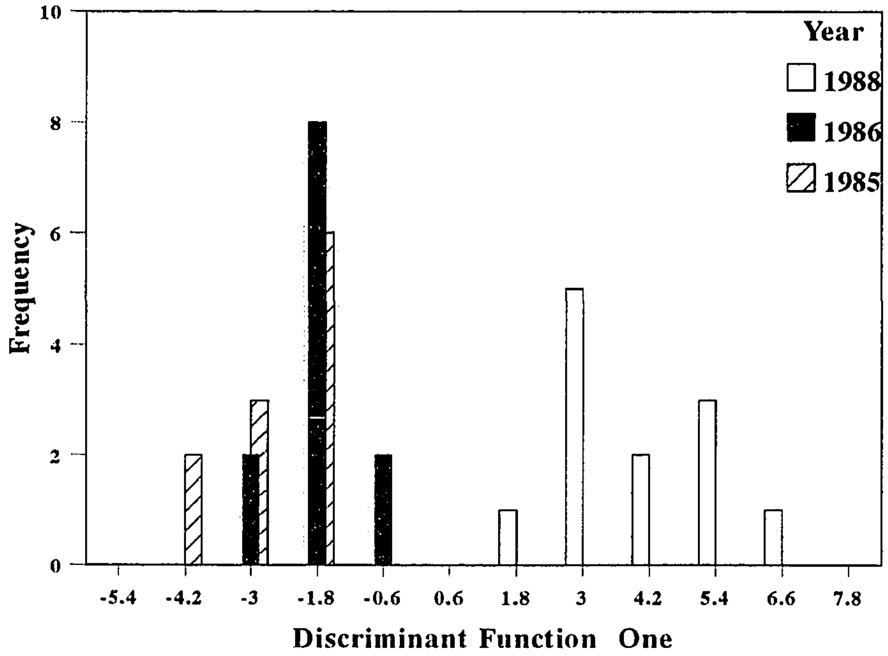
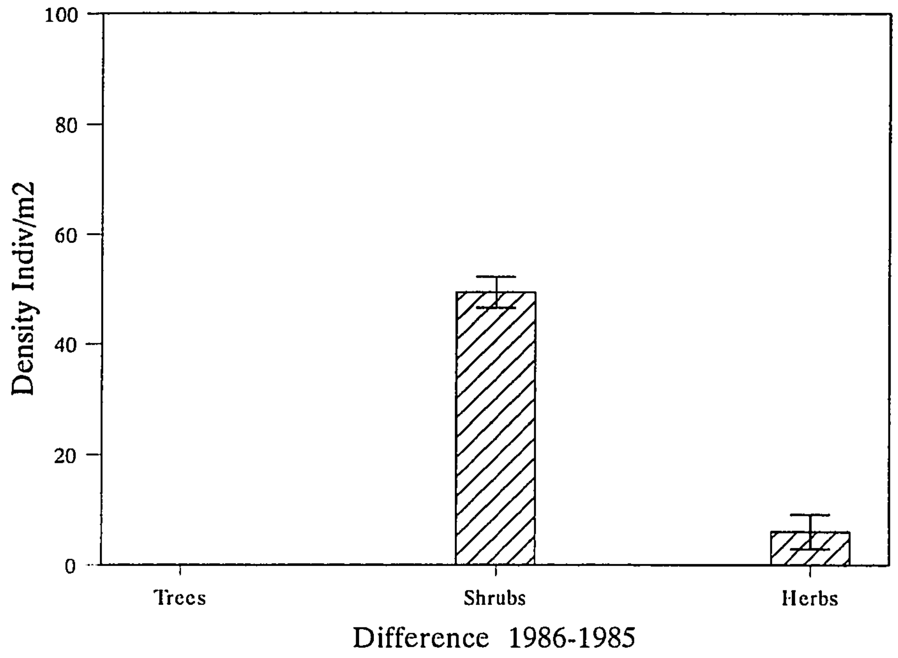
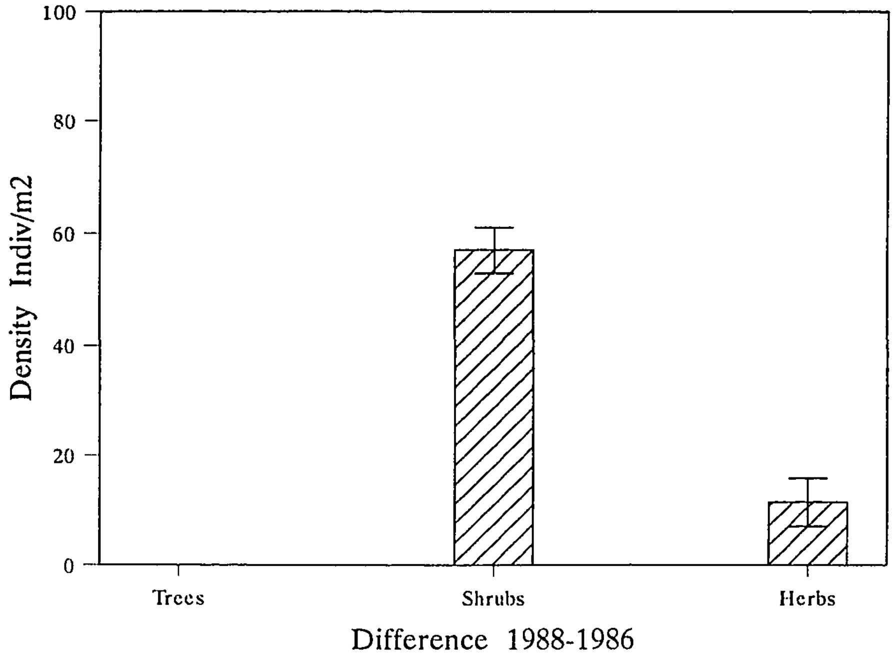

Year
1988
1986
1985
Frequency
10
8
6
4
2
0
-5.4
-4.2
-3
-1.8
-0.6
0.6
1.8
3
4.2
5.4
6.6
7.8
Discriminant Function One

Figure 3. Statistically significant understory responses by life form. A. Barrens 1, B. Barrens 2.

A.


100
80
60
40
20
0
Density Indiv/m2
Trees
Shrubs
Herbs
Difference 1986-1985

B.


100
80
60
40
20
0
Density Indiv/m2
Trees
Shrubs
Herbs
Difference 1988-1986

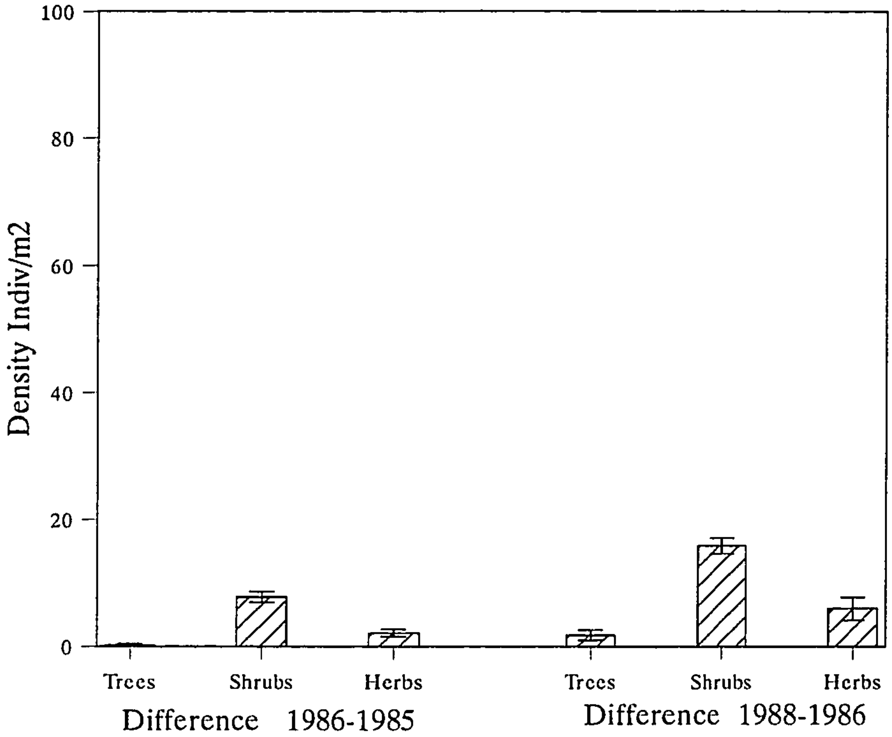
G. dumosa (IV's = 21.6, 21.3). As in Barrens 1, the same species that were dominant before the fire remained so afterward. In addition, however, *V. tenellum*, another very low shrub, became a dominant after the fire even though it was not detected in preburn samples, perhaps because of the small sample size and its initially low density. The results of the statistical tests were, for the most part, not significant. The results of a repeated measures Anova showed that there was an increase in understory density the year after the fire. Similarly a Canononical Discriminant Analysis found no difference between species. As in Barrens 1, paired t-tests showed that only shrubs increased in density as a whole (figure 3).

Of the prefire dominants in Mesic Area 1, *V. corymbosum, C. alnifolia* and *P. melanocarpa* exhibited marked decreases in IV following the fire (14.0 to 5.7, 12.5 to 6.1 and 12.0 to 0.50, respectively) and *P. melanocarpa* decreased in number as well ($1.2/m^2$ to 0.2). Only *G. frondosa* remained dominant throughout. *P. aquilinum* and *A. rubrum* (which was absent from preburn samples) became second and third highest in importance. The results of a repeated measures Anova showed that increases in understory density occurred in both the first and second years after the fire, but that differences between species in amounts of increase only occurred in the second year. *G. frondosa, P. aquilinum* and *A. rubrum* increased more than the mean. Similarly a Canononical Discriminant Analysis showed that differences between species existed not between pre-fire and the first year post-fire, but between the first and second year following fire. T-tests showed that shrubs as a whole increased in the first year after the fire and that shrubs and herbaceous species increased in the second year after the fire (Table 1, figures 2 and 4).

In Mesic Area 2, as in Mesic Area 1, the pre-fire dominant (*V. corymbosum*) decreased in IV after the fire (13.6 to 3.4) and in fact decreased in density (2.1/m^2 to 1.3). Unlike in Mesic Area 1, *P. aquilinum* in Mesic Area 2 decreased markedly in importance (11.1 to 3.0). The other pre-fire dominants, *S. glauca* and *C. alnifolia*, did not change markedly in importance. The results of a repeated measures Anova showed that understory density increased in the first year after the burn and *R. nudiflorum* increased more than the mean. The results of a Canononical Discriminant Analysis were not significant, perhaps because understory density increased less than in other areas. As in Mesic Area 1, tree seedlings showed a more distinct increase in density than in the more xeric areas (5/m^2 vs. 1) (Table 1).

As they did in Mesic Area 1, *A. rubrum* and *P. aquilinum* made dramatic increases in importance following the fire in the Swamp (0 to 24.4, 0 to 6.9). The dominant species, *C. alnifolia*, decreased in density following the fire, as did the

Figure 4. Statistically significant understory responses by life form. Mesic Area 1.


100
80
60
40
20
0
Density Indiv/m2
Trees
Shrubs
Herbs
Trees
Shrubs
Herbs
Difference 1986-1985
Difference 1988-1986

dominant understory species in Mesic Area 2. Unlike these areas, however, *V. corymbosum* remained high in importance throughout and unlike any other area in this study, a strong pre-fire dominant, *M. virginiana*, was eliminated from the understory sample. The Swamp was also unique in that the results of a repeated measures Anova showed that understory density increased only in the first year following fire, but *A. rubrum* increased more than average in the second year. Perhaps because of low sample size, a Canononical Discriminant Analysis was not significant (Table 1).

Study 2

Edaphic Effects

Soil pH varied between 4.1 and 4.9. A one-way Anova showed no difference between burned and unburned treatments for either exchangeable $H+$ or $Al+3$. Concentrations of all nutrients were low to very low (Table 2). One-way Anovas by season showed significant differences in concentration between seasons for calcium ($p = .016$; summer = 30 ppm, winter = 42 ppm) and for manganese ($p = .021$; summer = 0.64 ppm, winter = 1.35 ppm). No other nutrients showed differences between summer and winter concentrations. A one-way Anova of burned vs. unburned treatments showed significantly greater concentrations of phosphorus in burned areas ($p = .029$; burned = 2.0 ppm, unburned = 1.2 ppm). A one-way Anova showed significant difference in potassium concentration between

Table 2. Mean concentations of available soil nutrients (with standard deviations) for the study area, Nansemond County, Virginia (USDA, 1959), humid temperate soils (Brady, 1990) and Minnesota forests (Tappeiner and Alm, 1975).

	(meq/100g)			(%)	(ppm)					
Site	Exch. Acidity	Exch. Al	Exch. H+	Org C	NO3 N	P	K	Ca	Mg	Mn
Zuni Barrens 1988	.72	.36	.36	.70	1.0	1.5	9.4	37.6	4.0	1.0
SD	.19	.12	.17	.32	0	1.5	2.3	12.9	3.7	.88
Nansemond Co. 1959			16.20	6.80	25.1	40.9	113.4	481.7	97.4	5.7
SD			14.20	8.00	-	60.9	77.9	351.9	119.6	8.1
Humid Temperate Soils							84.6	1002.0	200.4	
Minnesota Forests					4.9	3.5	16.5	89.2	11.4	

plots ($p = .042$). Plot 1-4 (6.8 ppm) differed from plot 2-2 (12.5 ppm). A nested Anova showed a significant difference between treatments ($p = .015$) and no significant plot effect for magnesium concentration. Burned, not logged (5.4 ppm) differed from mechanically cleared and logged (3.1 ppm).

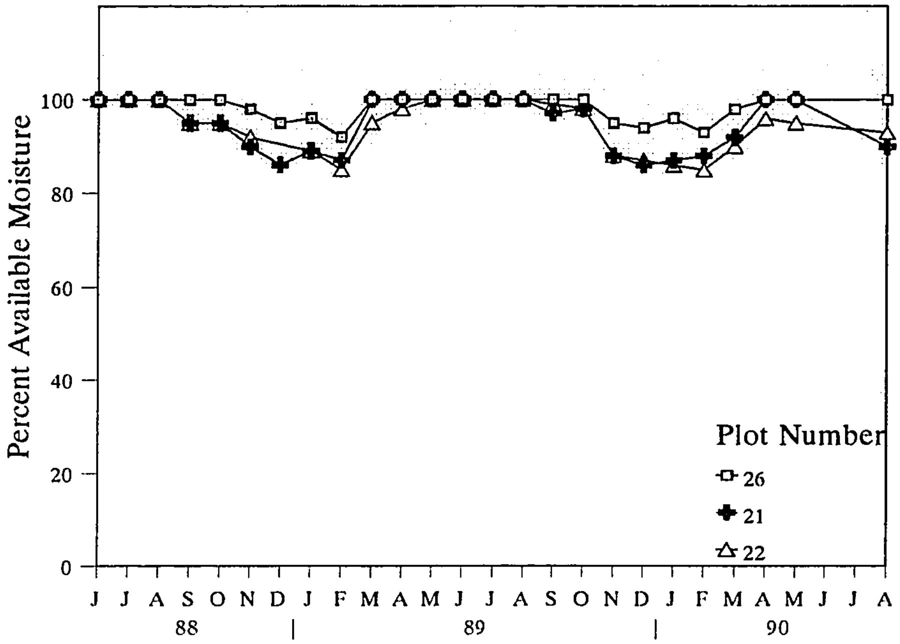
A nested Anova showed a significant difference between treatments ($p = .0001$) and between plots within treatments ($p = .003$) for available soil moisture. A one-way Anova found plots to differ significantly ($p = .0001$). Plot 2-6 (the wettest) differed from 1-3, 1-4, 2-3 and 2-4 (the four driest), and the wet plots 2-1 and 2-2 differed from 1-3 and 1-4 (the two driest). In the four driest plots, available moisture fell below 75% (critical stress threshold) in every summer of the study (figure 5).

Seed Production and Sexual Reproduction

From 1986 to 1988, no understory seed production occurred in sample plots. In 1989, a small number of seeds were produced in burned plots: 32.3 fruits/m^2 for shrubs and 0.36/m^2 for herbaceous plants. In mechanically cleared plots, even less seed production occurred: 1.8 fruits/m^2 for shrubs and 0.34/m^2 for herbaceous plants. Annual tree seedfall was 3.3 seeds/m^2 in 1987, 5.7/m^2 in 1988 and 4.1/m^2 in 1989. In 1987, the predominant seed producers were *P. palustris* (1.6 seeds/m^2) and *P. serotina* (1.4/m^2). *P. taeda* produced the most seeds in 1988 (4.6 seeds/m^2). In 1989, *P. taeda* (2.1 seeds/m^2) and *P. serotina* (1.8/m^2) were most productive.

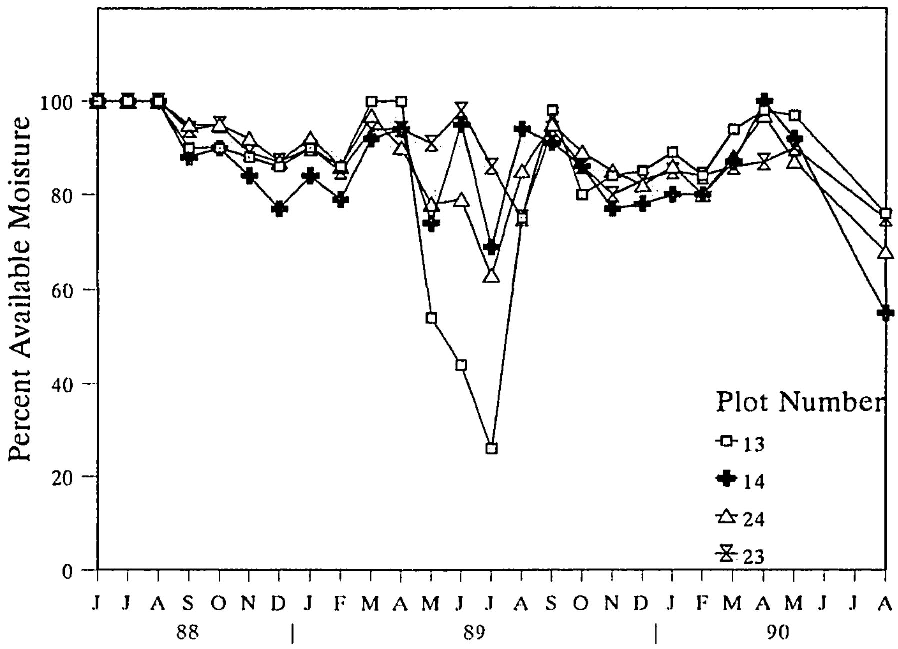
Figure 5. Monthly available soil moisture.
A. Plots with higher moisture levels.
B. Plots with lower moisture levels.

A.



Percent Available Moisture
100
80
60
40
20
0
Plot Number
26
21
22
J J A S O N D J F M A M J J A S O N D J F M A M J J A
88
89
90

B.



Percent Available Moisture
100
80
60
40
20
0
Plot Number
13
14
24
23
J J A S O N D J F M A M J J A S O N D J F M A M J J A
88
89
90

Examination of the soil seed bank yielded similar results for both burned and unburned areas. In the burned area, a mean of 8.5 seeds or spores/.14 m^2 germinated, while a mean of 10.7/.14 m^2 germinated in the unburned treatment. Species composition was also similar between burned and unburned areas. Four categories of species occurred: herbaceous perennial species of sandy woods (*C. nigromarginata, Panicum lanuginosum* and *Heterotheca nervosa*), invasive annual weeds (*E. hieracifolia* and *Eupatorium capillifolium*), mesic site ferns (*P. aquilinum*) and hydric site ferns (*W. areolata* and *Dryopteris spp.*).

The fate of *P. palustris* seedlings was carefully monitored. In the winters of 1987-1988 and 1988-1989 a total of 37 natural seedlings were established in Burn Area 1. Mortality was fairly evenly dispersed over 1988, 1989 and 1990 (4, 10 and 8 dead, respectively). By Dec. 1990, total *P. palustris* seedling mortality was 59.5%. In the lichen / seedling mortality study, 42 local, planted 1-0 *P. palustris* seedlings were observed for 20 months from March 1990 to November 1991. Seedling mortality was 45.2% in a barrens opening devoid of shrub coverage. In a 1 ha *P. palustris* plantation in Burn Area 2, 588 1-0 seedlings were planted in March 1990, two years after the area was burned. After 20 months, by November 1991, seedling mortality was 86.9%.

Understory Population Dynamics

In general, for the five treatments in Study 2, the numbers of shrub species sampled were either less than or equal to the numbers sampled in the Barrens of Study 1 (7 to 15 species vs. 14). On the other hand, the numbers of tree seedling and herbaceous species sampled in Study 2 were consistantly higher (for trees, 10 to 13 species vs. 3 to 7; for herbs, 10 to 14 species vs. 2 to 4). In addition, in the Second Study, larger numbers of shrub and herbaceous species were found in unburned plots than in burned plots. The numbers of tree species sampled were similar across all treatments. Species composition was very similar across all treatments in Study 2 and both Barrens of Study 1. Densities, however, differed markedly between the Barrens of Study 1 and the openings of Study 2. Overstory and understory densities were higher in Study 1 (overstory, 8.5/100 m^2 vs. 5.2; understory, 125.7/m^2 vs. 54.3). Sapling densities were higher in Study 2 (6.7/100 m^2 vs. 1.5).

As in the overstory and sapling layers, the more open areas sampled in Study 2 had a greater abundance of *Q. laevis* in the understory. Herbaceous species composition, on the other hand, differed considerably between the more open areas and Barrens 1 overall. *P. aquilinum* was the dominant herbaceous species following fire in all habitats in Study 1. In Study 2, *P. aquilinum* was either absent or not among the dominants in Barrens 1. The strongly dominant herb in these open areas was *C. nigromarginata*. Also dominant here were the pine barrens perennial herbs, *Euphorbia ipecacuanhae* and *C. stimulosus* and, briefly, the invasive annual, *E. hieracifolia*.

Statistical analysis of understory population dynamics in the second study yielded very interesting results. In the Barrens Areas of Study 1, and in two of the three wetter areas, the understory increased in density only in the first year following fire. In the more open areas sampled in Study 2, the understory increased in density between the second and third years in both burned and mechanically cleared treatments. In fact, understory density in the control treatment increased between the same two years.

In Barrens 1 and 2, overall population dynamics were dominated by shrub species. Perhaps because the sampling intensity was too low, herbaceous species exhibited no significant increases in density in the Barrens of Study 1. One tree species, *S. albidum*, in Barrens 1 was found to increase in density. In all treatments *C. nigromarginata* increased more than any other tree or herbaceous species between 1988 and 1989. In all except the mechanically cleared and logged treatment, *P. lanuginosum* increased more than other species between 1989 and 1991. Burned treatments differed from the others in that *P. taeda* increased (Table 3).

A doubly multivariate repeated measures Anova showed that the mechanically cleared, not logged and control treatments were similar to each other and the mechanically cleared and

Table 3. Study 2. Understory species exhibiting statistically significant population increases.

Herbaceous Plants and Tree Seedlings				
Burned		Mechanically Cleared		Control
Logged	Not Logged	Logged	Not Logged	
C.nigromarginata	*C.nigromarginata*	*C.nigromarginata*	*C.nigromarginata*	*C.nigromarginata*
P.lanuginosum	*P.lanuginosum*	*P.polygama*	*S.odora*	*P.lanuginosum*
	P.taeda			*S.odora*
	Q.nigra			

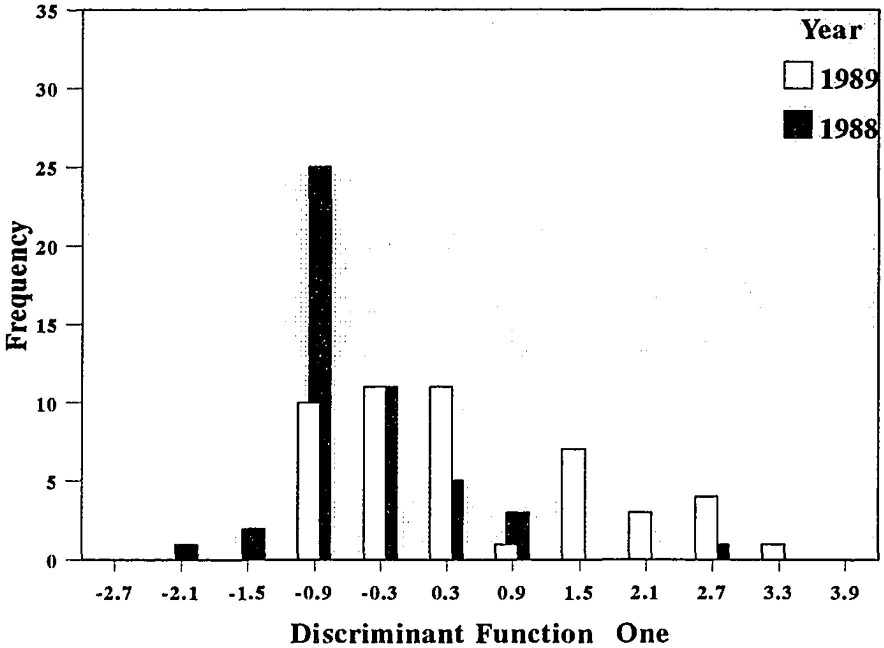
logged treatment was grouped with the burned treatments. In addition, all treatments had similar *C. nigromarginata* and *P. lanuginosum* increases and all treatments showed overall increases. The treatments differed in tree seedling dynamics (Table 3, figures 6, 7 and 8).

<u>Study 3</u>

A one-way Anova by treatment (Lichen, No Lichen, Lichen Removed) on *P. palustris* seedling mortality was not significant. A nested Anova showed a significant difference between treatments (Lichen, No Lichen) ($p = .014$) and no significant plot effect for *P. taeda* seedling density. The Lichen treatment had greater seedling density. A nested Anova showed no significant difference between treatments (Lichen, No Lichen) and no significant plot effect for *P. taeda* seedling mortality (figure 9).

Figure 6. Separation between years by Canononical Discriminant Analysis. A. burned, not logged treatment, B. burned and logged treatment.

A.


Year
1989
1988
Frequency
35
30
25
20
15
10
5
0
-2.7
-2.1
-1.5
-0.9
-0.3
0.3
0.9
1.5
2.1
2.7
3.3
3.9
Discriminant Function One

B.

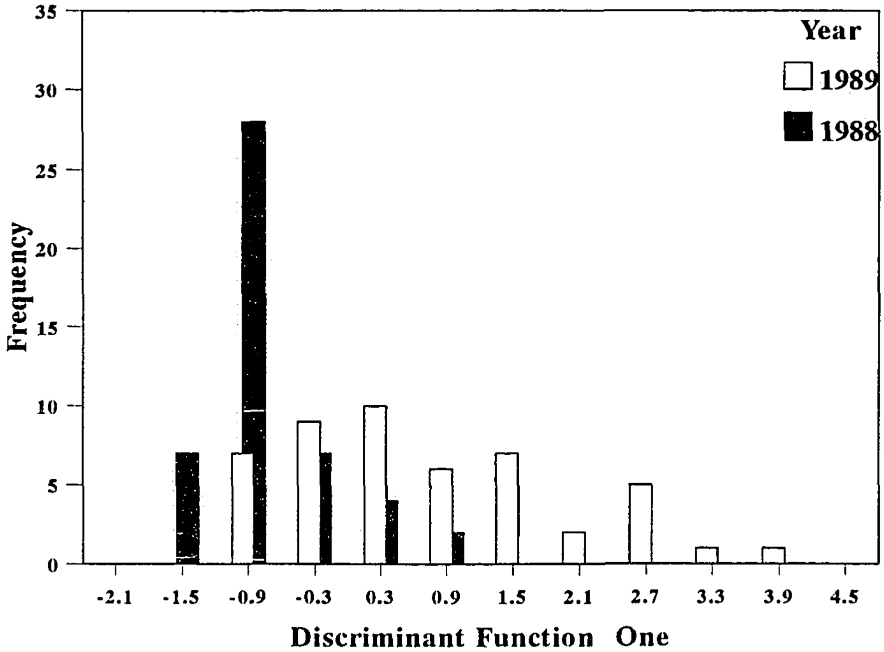
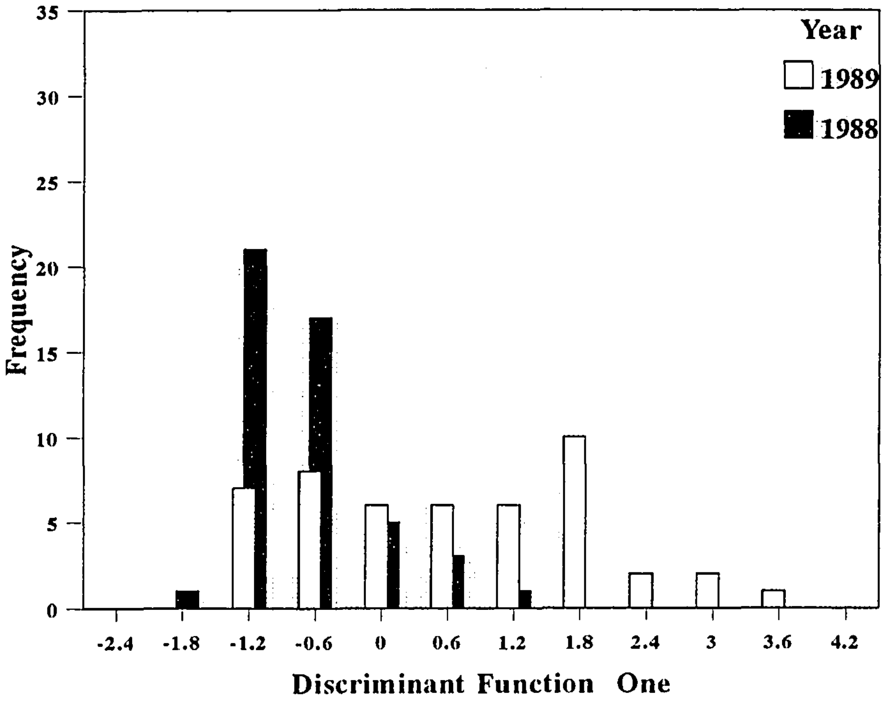

Year
1989
1988
Frequency
35
30
25
20
15
10
5
0
-2.1
-1.5
-0.9
-0.3
0.3
0.9
1.5
2.1
2.7
3.3
3.9
4.5
Discriminant Function One

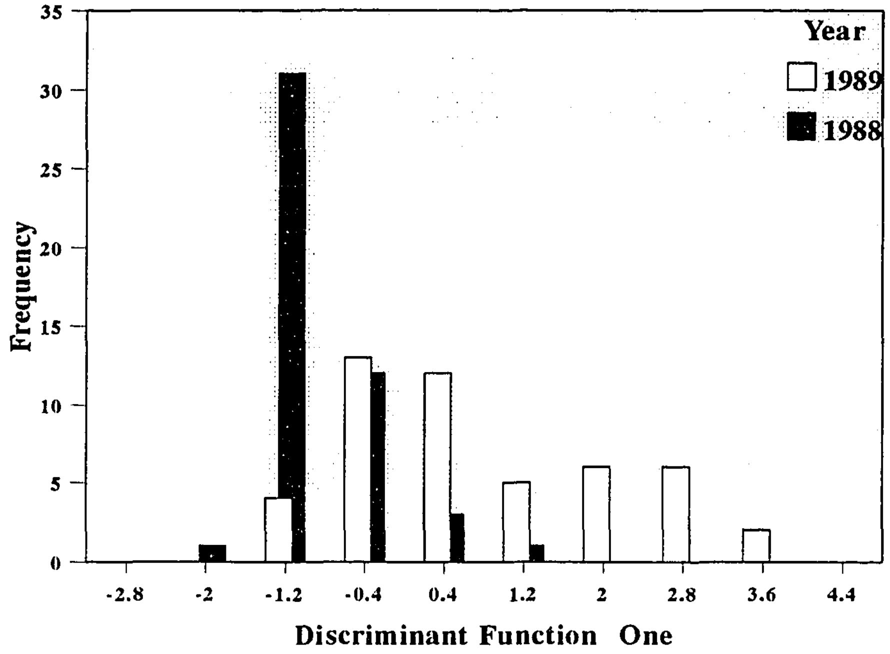
Figure 7. Separation between years by Canononical Discriminant Analysis for the mechanically cleared, logged treatment.



Year
1989
1988
Frequency
35
30
25
20
15
10
5
0
-2.4
-1.8
-1.2
-0.6
0
0.6
1.2
1.8
2.4
3
3.6
4.2
Discriminant Function One

Figure 8. Separation between years by Canononical Discriminant Analysis. A. mechanically cleared, not logged treatment, B. control treatment.

A.


Year
1989
1988
Frequency
35
30
25
20
15
10
5
0
-2.8
-2
-1.2
-0.4
0.4
1.2
2
2.8
3.6
4.4
Discriminant Function One

B.

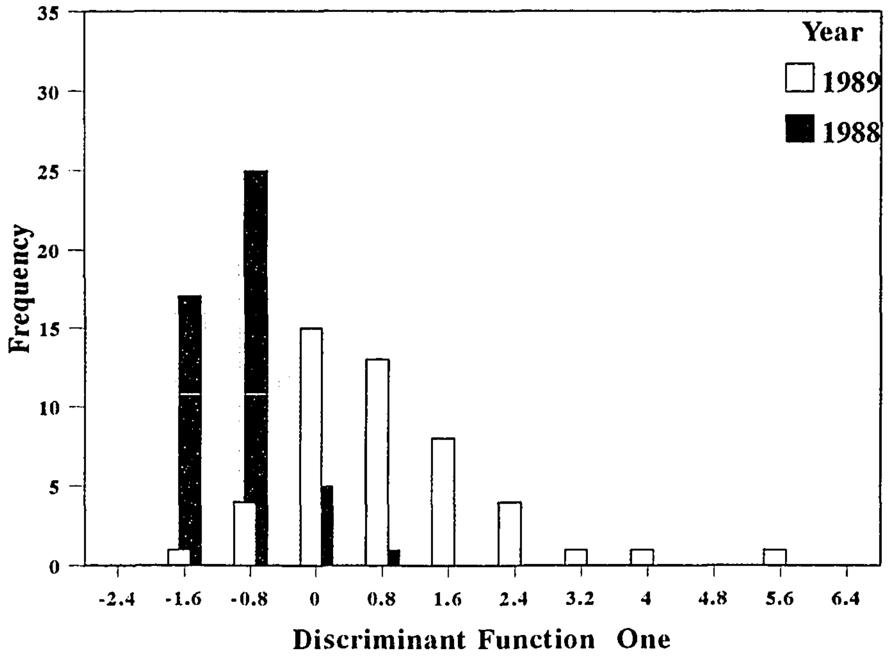
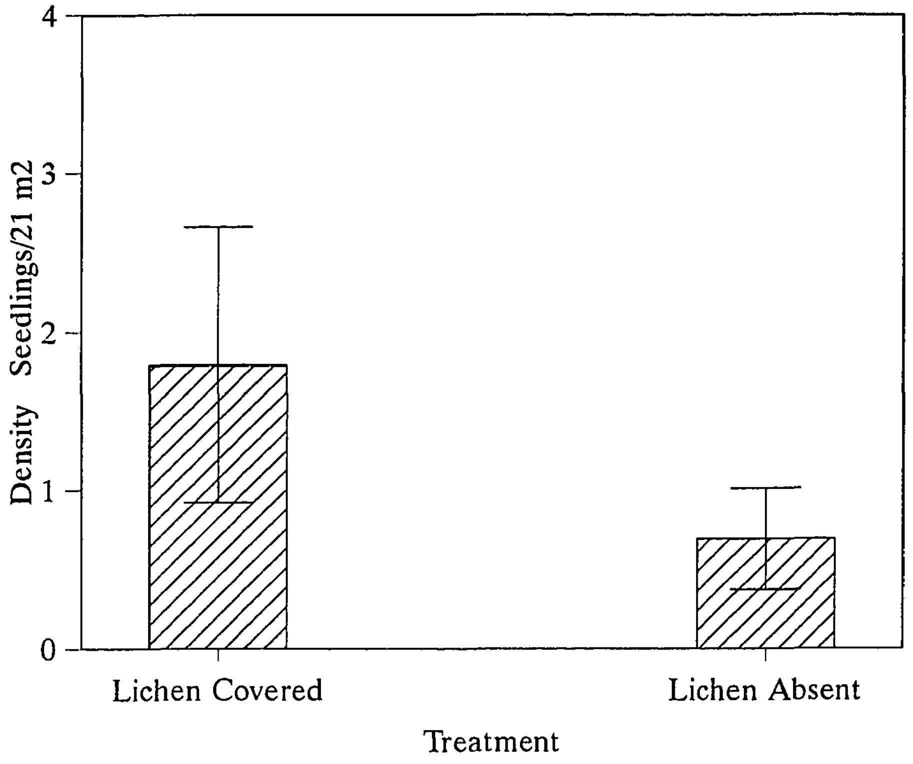

Year
1989
1988
Frequency
35
30
25
20
15
10
5
0
-2.4
-1.6
-0.8
0
0.8
1.6
2.4
3.2
4
4.8
5.6
6.4
Discriminant Function One

Figure 9. Statistically significant difference in *P. taeda* seedling density between treatments (Lichen Covered, Lichen Absent). n = 120.


4
3
2
1
0
Density Seedlings/21 m2
Lichen Covered
Lichen Absent
Treatment

DISCUSSION

Study 1

In both burn areas and in all habitats on mineral soil, certain similarities are apparent. Overstory mortality was moderate to severe (19.0%-46.7%) while sapling/large shrub mortality was very severe (73.9%-90.2%). Across all of these areas, with the exception of Mesic Area 2, mortality was concentrated in the first year following the burn. In addition, in both xeric and mesic habitats and in the overstory and sapling layers, two of the species most severely affected were *Q. laevis* and *S. albidum*, which in many cases were completely lost from the sample. *Q. laevis*, a small multi-stemmed scrub oak, dependent on fire, appears to behave similar to its more northern counterpart, *Q. marilandica*. In two wildfires on xeric sites in the New Jersey Pine Barrens, *Q. marilandica* exhibited 100% aboveground mortality and then sprouted profusely from stumps and root systems (Buchholz, 1983).

In Barrens 1, *P. palustris*, known to be the most fire resistant of southern pines (Sirmon and Dennington, 1989; Burns, 1983), became the dominant overstory and sapling layer species.

In addition, a number of species associated with wetter sites and not thought to be fire dependent (*I. opaca, V. corymbosum, A. canadensis, M. virginiana, and N. sylvatica*) were lost from overstory and sapling layer samples. This follows the common phenomenon associated with xeric, fire prone communities that, in the absence of fire, wet site species encroach onto more mesic sites but are eliminated when fire again occurs (Zampella et al., 1992; Frost et al., 1986).

The overstory and sapling layers of Barrens 2 were somewhat unique in both composition and dynamics. Although the typical pine barren species, *P. palustris* and *Q. laevis*, were common, the overstory and sapling layers were strongly dominated by *P. serotina*. *P. serotina*, although a fire dependent species, is not generally thought to dominate xeric, sandy, fire-prone sites. It is known to be somewhat less fire resistant then *P. taeda* and may invade drier sites in the absence of fire (Fowells, 1965). This area is underlain by a spodic horizon which impedes downward percolation and may maintain a relatively high water table in spite of the deep, sandy soil. This may explain the coexistence of xeric and mesic dominants.

As is very often the case for mid-successional forests of the mid-Atlantic Coastal Plain, the overstory of Mesic Area 1 was strongly dominated by *P. serotina* and *P. taeda,* while the encroaching hardwoods, *A. rubrum* and *N. sylvatica* are present at a considerably lower level of dominance. The dense sapling/large shrub layer, although strongly dominated by *V. corymbosum*, contained these same four tree species in roughly equal amounts, demonstrating the successional replacement of pines by hardwoods. The effect of fire here was rather surprising, however. The dominant overstory species, *P. serotina* and *P. taeda*, suffered the greatest relative mortality and maintained dominance simply by virtue of their initial high density. On the other hand, *A. rubrum*, not generally thought of as fire resistant, suffered low mortality (20.0%) and increased in importance. A similar trend was seen in the sapling/large shrub layer. Even though *V. corymbosum* and *A. canadensis* decreased more than *A. rubrum, N. sylvatica* and several other species, *V. corymbosum* remained strongly dominant due to its high initial density. And again, *A. rubrum* and *N. sylvatica* had low mortality and increased in IV while *P. serotina* and *P. taeda* had high mortality and decreased. It seems unusual that pines would suffer from fire to a greater degree than hardwoods (Fowells, 1965).

Understory layers in all habitats exhibited great increases in numbers of individuals (three to ten-fold) and numbers of species (two to four-fold). The increases were predominantly (>90%) vegetative. Platt et al. (1987) in Florida pine savannahs and Reiners (1965) in Long Island N.Y. pine barrens also found regeneration following fire to be almost entirely due to vegetative sprouting of long lived perennials.

Increases in number were predominantly by shrubs, especially in more xeric areas, where shrubs made up 85%-89%

of the increases. The wetter areas had larger proportions of herbaceous species and had greater species diversity (24 to 42 species vs. 21 to 22) and greater increases in species diversity (two, three and four-fold vs. two-fold) than the xeric areas. Frost et al. (1986) and McCormick (1979), in southern pine savannahs and New Jersey pine barrens respectively, both found greater species diversity in wetter sites. As expected in mid-successional forests, all sites had very low densities of tree seedlings and herbaceous species (except for *P. aquilinum*) before the fires. Although increases in numbers of individuals and numbers of species of trees and herbs were noted at all sites ($2/m^2$ to 5, trees; $5/m^2$ to 10, herbs), they were far less numerous than shrubs ($10/m^2$ to 60). However, it seems that the sampling intensity was too low to adequately represent tree seedlings and herbaceous species. With the exception of *A. rubrum, P. aquilinum* and *E. hieracifolia* at two sites, no tree or herbaceous species displayed significant statistical results. Tree seedling and herbaceous densities were comparable with other studies. Following wildfire on xeric sites in the New Jersey pine barrens, Boerner (1981) found *P. rigida* densities ranging from $0.34/m^2$ to 1.58 and herbaceous cover of less than 10%. Following fire in Alabama *P. palustris* stands, Croker and Boyer (1975) found *P. palustris* seedling densities ranging from $1.6/m^2$ to 3.26. In xeric sites in the present study, post fire pine seedling densities averaged $0.95/m^2$ and herbaceous species accounted for a mean of 4.5% of the total understory density.

As in the present study, Boerner (1981) found that in several xeric stands in the New Jersey Pine Barrens, *G. baccata* dominated the understory following wildfires and prescribed burns and also in unburned controls. The results of the present study are not consistant with those of Buell and Cantlon (1953) however. They found that prescribed burns on xeric sites in the New Jersey pine barrens caused decreases in *G. baccata* densities while *V. vaccilans* rapidly increased. In addition, as in the present study, Boerner (1981) found *G. procumbens* among the dominants after wildfire and prescribed burns while Buell and Cantlon (1953) found *G. procumbens* to decrease in response to fire.

Understory population dynamics in Mesic Area 1 differed greatly from those in the more xeric habitats. Numerous dominance shifts occurred following the fire and statistical analysis showed that tree and herbaceous species exhibited major population increases. As in the present study, McCormick (1979) found *G. frondosa* among the dominant shrubs and *P. aquilinum* the dominant herb in *P. rigida* lowland forests of the New Jersey Pine Barrens and Little (1979) found that *P. aquilinum* may dominate in the first year after fire.

E. hieracifolia increased between the first and second years following fire. *E. hieracifolia* was dominant among a species complex of invasive, old field annuals which were common in all burned habitats in this study: *E. hieracifolia, E. canadensis* and *E. capillifolium*. These species briefly appear after disturbance temporarily increases light availability (Radford et al., 1965).

As in the Swamp in the present study, McCormick (1979) found *V. corymbosum* and *C. alnifolia* to be the dominant shrubs in maple-gum swamps in the New Jersey Pine Barrens and Little (1979) found *A. rubrum* to be among the dominants in post-fire regeneration in New Jersey swamps.

Platt et al. (1987) and Reiners (1965) found regeneration following fire, in Georgia pine savannahs and New York barrens respectively, to be predominantly vegetative. Such was the case in the present study, but with interesting exceptions. In all areas, *P. melanocarpa, S. glauca* and *S. rotundifolia* reproduced equally by seed and vegetative sprout. In both Barrens and in Mesic Area 2, *S. albidum* reproduced equally by seed and sprout but in the Swamp and Mesic Area 1, it regenerated strictly vegetatively. In the Swamp and Mesic Area 1, *C. alnifolia* reproduced predominantly by sprout but in Mesic Area 2, it regenerated equally by sexual and vegetative means.

In the Mesic Area 1, *A. rubrum* regenerated predominantly by seed but in Mesic Area 2 and in the Swamp it regenerated equally by sexual and vegetative means. Reiners (1965) found that *V. vaccilans* regenerated predominantly vegetatively. In disturbed areas, however, it also reproduced by seed. In the present study, *V. vaccilans* was found to reproduce equally by seed and by vegetative sprout in Barrens 1 but only by sprout in Barrens 2.

Study 2

Edaphic Relationships

In the present study, soil nutrient levels were very low in comparison to many other forest soils (Brady, 1990). However, levels were comparable to those reported for other *P. palustris* and *P. taeda* forests on sandy soils in the southeastern United States. Kormarek (1974) found that nutrient increases following forest fires were quickly leached or taken up by vegetation and thus were not evident one year after burning. In the present study, phosphorus was the only nutrient which differed between burned and unburned treatments, with 2.0 ppm in burned plots versus 1.2 ppm in unburned. McKee (1986), who studied fire effects in nine *P. taeda* and *P. palustris* stands, found phosphorus to be the only nutrient consistently increased by burning and, in South Carolina, phosphorus concentration was 1.4 ppm in burned stands and 1.1 ppm in unburned stands. Waldrop et al. (1987) found similar differences in South Carolina stands (1.6 ppm in burned stands and 1.25 ppm in unburned). As in the present study, McKee (1986) found no difference between calcium levels in burned and unburned stands and, in South Carolina, calcium concentrations averaged 58.0 ppm as opposed to 37.6 ppm in the present study. Waldrop et al. (1987), on the other hand, found calcium concentrations to be 59.2 ppm in burned stands compared to 46.8 ppm in controls but did not statistically analyze the data. It is commonly accepted that nutrient levels are higher in winter when vegetation is dormant (Brady, 1990). In this study, however, only calcium and manganese concentrations were higher in winter and plots with trees removed did not show higher concentrations than unlogged plots. Perhaps these contradictions are related to the extremely low overall nutrient levels revealed by this study. The only other nutrient differences found seemed to reflect patchy, highly variable distributions. The Soil Conservation Service reports that nutrient levels, particularly calcium and magnesium, are low and extremely variable on Leon-Chipley sands (Isle of Wight Co. Soil Survey, 1987).

Moisture relationships in the present study were somewhat surprising. Precipitation for the five years during the major portion of this study (1985-1989) was extremely close to the previous thirty year average (122 cm). The years 1987, 1988 and 1990 were below normal, 1985 and 1989 were above normal and 1986, while below normal, was above normal for the growing season (NOAA, 1990). Pine barrens on deep sands are known to be xeric and droughty and White et al. (1988) stated that the moisture levels are often around 3.0% in North Carolina barrens. In the present study, however, over the two years measured, all plots averaged greater than 80 % available moisture and 40% of the plots averaged greater than 90% available moisture (8% by volume).

Moisture varied significantly between plots. Fire did not seem to affect moisture levels, since two of the driest plots were burned and two were unburned. Since all plots contained xeric vegetation, and since moisture levels were measured only once a month, perhaps the controlling factor is not overall dryness, but rather rapid fluctuation or droughtiness. In fact, Lowenthal (1990) found percolation on these sites to be rapid to very rapid and Wahlenberg (1946) referred to North Carolina pine barrens as "deserts in the rain". In the present study, xeric conditions did occur in the summers. At the four driest sites, available soil moisture dropped below 75% each year during the growing season (and in one plot to 23%). Plants in humid, temperate climates experience moisture stress when available moisture falls below 75% (Bouyoukos, 1971).

Seed Production and Sexual Reproduction

In many plant communities, following disturbance, reproduction can be due to seeds from a buried seed bank which can remain viable for 50 years or more. A North American maple forest was found by Nakagoshi (1985) to have 378 viable buried seeds/m^2, with the dominant species being invasive weeds and early successional species. In his study of several successional stages in Japanese forests, Nakagoshi (1985) found from 284 to 5480 buried seeds/m^2. Dominant among buried seed populations was the *Eupatorium* type: perennial forbes and graminoids. Within this type, a species of *Carex* was found to have 12.5 to 75.0 buried seeds/m^2. A second group, the *Erigeron* type, was made up of annual weeds and was found to be absent or present at very low densities in forest soils. In this group, *Erigeron sumatrensis* was found to have from 0 to 2.5 buried seeds/m^2.

In the present study, from 60 to 75 germinated seeds/m^2 were found. Seedlings from the *Eupatorium* type (*C. nigromarginata, P. lanuginosum* and *Heterotheca nervosa*) and the *Erigeron* type (*E. hieracifolia, E. capillifolium*) were found in similar numbers in all plots. Seedlings of *C. nigromarginata* ranged from 3.6/m^2 to 26.3 while those of *E. hieracifolia* ranged from 10.7/m^2 to 12.9. As expected, given the strategy of lying dormant in the soil until disturbance occurs, numbers of seedlings did not differ between burned and unburned plots. In addition to seedlings of Angiosperms, germinated spores of three fern species occurred: *P. aquilinum*, and two wet site species; *W. areolata* and *Dryopteris* spp. It is interesting that viable propagules may remain in the soil for years when the habitat may never be appropriate for their establishment. Reference to fern spores remaining dormant for many years in a soil seed bank could not be found.

Since *P. palustris* is a threatened species at the northern limit of its range in southeastern Virginia, great care was taken to assess its reproductive success following the fires. Seedling establishment was extremely poor, considering that a relatively heavy seedfall occurred in the fall following the fire. Only about 5 seedlings/ha were established in Barrens 1. One explanation may be that the trees were only 32 years old. Although, capable of producing cones at that age, the amount produced is far less than mature trees of 80+ years (Platt et al., 1988).

Cones were harvested from *P. palustris* trees on site and 588, 1-0 seedlings were planted in a 1 ha area of suitable habitat. Percent mortality from the two areas is informative. White et al. (1988) reported that in over 200 sampled plantations, using 12 different "appropriate" site preparation methods, *P. palustris* seedling mortality ranged from 31.7% to 89.2%. In the present study, however, *P. palustris* natural regeneration mortality, when established four to five months after fire, was 59.5%. In the 1 ha plantation, which had been burned two years before, a heavy ericaceous shrub cover was present and mortality was 86.9%. Croker and Boyer (1975) found that *P. palustris* seedlings are extremely susceptable to shrub competition and site preparation must occur no more than one year before planting. The present study corroborated these findings in that understory population increases occurred in the first year following fire and not in subsequent years, and *P. palustris* seedling survival was very poor when planting was delayed until the second year.

Understory Population Dynamics

The second study concentrated on a distinctive subset within the overall, xeric pine barrens habitat: plots were positioned so as to contain several open areas, 20 m^2 to 100 in size dominated by herbaceous species, lichens, and bare sand. A disadvantage in the second study was that the plots were not in place in time to conduct preburn samples.

The vegetation of the Study 2 plots differed from the overall barrens vegetation mainly in structure. Species composition in these open areas was similar to that of the overall barrens. In Barrens 1, the overstory and sapling layers in both cases were dominated by *P. palustris, P. taeda* and *Q. laevis*. The more open areas, however, had relatively more *Q. laevis* and less *P. serotina* than the barrens as a whole. This, together with their more open nature, may reflect somewhat drier conditions in these openings (Fowells, 1965; Matoon, 1922). In both cases in Barrens 1, the dominant shrub species in the understory were *K. angustifolia, G. baccata* and *G. frondosa*, and tree seedlings were dominated by *S. albidum, Q. laevis* and *P. taeda*.

It is interesting to note that the mechanically cleared and logged treatment was similar to the burned treatments in tree seedling density and dynamics, while the control and mechanically cleared, not logged treatments had lower tree seedling densities and dynamics. It seems that removing the overstory reduces litterfall and allows mechanically cleared plots to exhibit tree seedling and herbaceous dynamics similar to burned plots. The mechanically cleared and logged treatment was the only treatment to have significant increases of *P. polygama* and *P. barbulata*. However, these species were not present in the area containing the burned treatments.

Since *C. nigromarginata* increased equally in control and cleared treatments, this study differs from those of Buell and Cantlon (1953) and Boerner (1981) who found that the closely related *C. pennsylvanica* increased markedly after fire when compared to controls in xeric stands in the New Jersey Pine Barrens. The behavior of *P. aquilinum*, on the other hand, appeared to be in agreement with that found in other studies. Buell and Cantlon (1953) found *P. aquilinum* to be very spotty in occurrence and to either increase or decrease following fire. Grubb (1985) found that *P. aquilinum* may be lost after fire because its vegetative regeneration was unable to make up for lost capital. Even though *P. aquilinum* was the dominant post-fire herbaceous species in all habitats sampled in Study 1, it decreased in density and frequency in Mesic Area 2. The fact that *P. aquilinum* dominated the herbaceous species in the overall survey of Burn Area 1 but was absent or very sparse in the more intensive surveys of the small areas used in Study 2 indicates a patchy distribution. A patchy distribution and a lack of tolerance for disturbance is further indicated by *P. aquilinum* being the dominant herbaceous species in the control and mechanically cleared treatments but absent or very sparse in the other treatments of Study 2.

It may be that the effect of disturbance in fire prone areas is to coordinate the responses of the dominant species: i.e. all dominant species increase, possibly due to increased light availability. Without disturbance, species' population dynamics may occur independently of one another, or, in response to inter-specific competition. This may explain why, in the xeric barrens areas, all dominant understory species increase following fire, all increases occur in the first year, and the same species remain dominant. On the other hand, in wetter areas less prone to fire, many dominant understory species decrease following fire and new species increase and become dominant, although increases are delayed until the second year. Possibly, the dominant species in less fire prone communities are less well adapted to respond to fire.

<u>Study 3</u>

For both planted *P. palustris* seedlings and naturally occurring *P. taeda* seedlings, the presence or absence of extensive lichen coverage has no effect on seedling mortality.

In addition, *P. taeda* seedling establishment is greater in dense lichen patches than in the absence of lichens. Perhaps lichens increase moisture retention at the soil surface compared to bare sand and are less competitive than low ericaceous shrubs. These results are contradictory to those of Ott (1961) whose laboratory studies showed that lichens may be allelopathic to spruce (*Picea*) seedlings. It is widely known, however, that allelopathic effects demonstrated in the laboratory are often extremely difficult to duplicate in nature.

SUMMARY AND CONCLUSIONS

In this study, fire resulted in moderate mortality in the overstory (40%) and heavy sapling/large shrub layer mortality (80%). Following nearly 100% aboveground mortality in the understory, density increased three to ten-fold, principally by vegetative regeneration, and the number of species doubled. In all habitats, shrubs strongly dominated the understory following fire. Shrubs made up from 82% to 94% of understory density and 67% to 89% of the increase in density. In most cases, the significant population dynamics occurred in the first year following fire.

For the most part, in the overstory and the sapling/large shrub layers, the same groups of species that were dominant before the fires, remained so afterward. The exceptions were

Q. laevis, in the barrens, which was severely depleted in both overstory and sapling layers, and *A. canadensis* and *P. serotina* in the sapling/large shrub layer of Mesic Area 1.

In the barrens understories, the species dominating before the fires increased the most and remained dominant. In Barrens 1 and 2, one species in each area (*G. frondosa* or *V. tenellum*, respectively) increased from insignificance to a position of dominance. In wetter areas, several dominant species (including the most dominant) were removed from positions of dominance and in some cases even decreased in number, while several previously insignificant species became dominant. This may indicate that understory communities in the drier areas are better adapted to respond to fire. As reported by other authors (Frost et al., 1987; McCormick, 1979) the wetter areas had greater understory species diversity (as much as twice that of the barrens), and a greater herbaceous component.

In all habitats, *P. aquilinum* dominated the herbaceous species following fire. As noted by Buell and Cantlon (1953), *P. aquilinum* distribution was very patchy and its response to fire extremely variable. Although greatly increasing in some areas, it remained stable, decreased or even disappeared in others.

In the Barrens, tree reproduction was dominated by *S. albidum* and *P. taeda*. In the wetter areas, *A. rubrum* dominated tree reproduction and in most cases equaled or surpassed shrub response.

An additional fire related effect was that, although present in very low numbers, several species present in Fernald's 1936 survey, but undetected before the fire, reappeared. In the barrens, *V. crassifolium* and *A. virgata* and in Mesic Area 1, *S. purpurea* and *H. blephariglottis* were noted.

One year after the fire, the only soil nutrient that remained at elevated levels was phosphorus. All nutrient levels were extremely low. In the barrens, soil moisture was variable and surprisingly high (80% - 98% average over two years), but did not differ between burned and unburned areas.

The open areas found in the barrens habitats were quite unique in appearance and structure and exhibited understory dynamics very different from the barrens overall, even though species composition was similar. Tree density was similar to the surrounding stand, but the trees were smaller in size. Tree seedling density was similar to the surrounding stand. Shrub density and herbaceous density were much lower and bare sand and extensive lichen patches were common.

Even though understory population increases in the surrounding stand occurred only in the first year following fire and were limited to shrub species, in the open areas dramatic increases occurred between the second and third years for tree, shrub and herbaceous species. In addition, the increases occurred in burned, mechanically cleared and control plots.

Since 1988 was a heavy seed year for *P. taeda*, an increase between 1988 and 1989 was reasonable. In these open areas, the burned treatments together with the mechanically cleared and logged treatment differed from the control and mechanically cleared, not logged treatments based upon tree seedling density and amount of increase. Due to reduced litter layer, the burned and cleared and logged treatments had greater tree seedling density and population increases than the control and mechanically cleared, not logged treatments.

C. nigromarginata was a dominant herbaceous species in all plots and *P. lanuginosum* in almost all plots, and these two species increased more than other tree or herbaceous species in all cases. These species were also common in these areas' soil seed banks. Control plots had similar herbaceous density and diversity to cleared plots. The burned treatments seemed to differ from the control treatment in that *E. ipecacuanhae* and *C. stimulosus* were dominant herbaceous species in burned plots while *Chimaphilla maculata* and *Cypripedium acaule* were more common in control plots.

Since these open areas have relatively sparse understories and the trees are growing more slowly, perhaps more spaces for colonization exist and the species present are able to increase in number more than in the surrounding stand. Or since such bare sand and open spaces are common here, lower fuel may cause fire effects to be less severe in the openings and species population increases are not as closely related to fire as in the surrounding stand.

The Zuni Pine Barrens, and possibly other Virginia barrens, appear to be quite different from southern *P. palustris* communities in understory species composition and post-fire understory dynamics. Even with a fire frequency of six to ten years, these southern *P. palustris* communities have understories strongly dominated by herbaceous species.

Florida *P. palustris* stands burned every six years (Platt et al., 1987) had an understory with more than 90% herbaceous cover, dominated by *Aristida stricta*. Among the shrub dominants were *Asimina longifolia, I. glabra, V. myrsinites* and *Callicarpa americana*. In burned *P. palustris* stands, Grelen (1975) found an understory with 88% herbaceous cover dominated by *Andropogon scoparius*. Shrub dominants were *Myrica cerifera, Rhus coppalina* and *C. americana*. In South Carolina, Waldrop et al. (1987) studied a mesic/hydric *P. taeda* stand with *V. corymbosum* and *C. alnifolia* dominating the understory. With burns every seven years, shrubs made up 67% of understory density and shrub density was only 14 stems/m^2. Perhaps most telling was Gilliam and Christensen's (1986) study. In a South Carolina *P. taeda* - *P. palustris* stand with a fire frequency of greater than ten years, one year after fire, shrub cover was 49% and herbaceous cover was 34%.

Andropogon virginicus dominated the understory and the dominant shrubs were *I. glabra, M. cerifera* and *V. tenellum*. They found that shrub cover and abundance did not differ from unburned controls, while burned stands had significantly greater herbaceous cover and species richness than controls.

Following fire in the Barrens areas in the present study, shrubs made up 94% of the understory density and 87% of the post-fire population increases. Shrub density averaged 100 stems/m^2. In the two Barrens studied, the dominant understory species were *K. angustifolia, G. baccata, G. frondosa* and *G. dumosa* in Barrens 1, and *G. procumbens, G. dumosa, V. tenellum* and *K. angustifolia* in Barrens 2.

Though trees of the southern pine barrens (*P. palustris, P. taeda* and *Q. laevis*) are dominant in the Barrens of the present study, understory species composition and post-fire dynamics are remarkably similar to those of the xeric pine-oak forests of the New Jersey Pine Barrens. There, *P. rigida* replaces the southern pines and *Q. marilandica* replaces *Q. laevis*. The understory, however, in areas with an 8 to 20 year fire frequency, is dominated by *G. baccata, K. angustifolia, V. vaccilans* and *G. procumbens* (Zampella et al., 1992; Boerner, 1981; McCormick, 1979). Shrubs makeup more than 90% of the understory cover (Boerner, 1981), and, even with a three year fire frequency, shrub cover was still 45% and herbaceous cover, though increased, was only 5.5%

(Reiners, 1965; Buell and Cantlon, 1953). The dominant herbaceous species after fire were very similar as well: *C. pennsylvanica, P. aquilinum, S. odora, A. scoparius* and *E. ipecacuanhae* (Boerner, 1981; McCormick, 1979).

In fact, the wetter areas in the present study had very similar understory species compositions to the pine-maple swamps of the New Jersey Pine Barrens. There, the understory was dominated by *V. corymbosum, C. alnifolia, A. canadensis* and *G. frondosa* (Zampella et al., 1992; McCormick, 1979). In order to hypothesize about the natural fire frequency in the Virginia pine barrens, one might start by comparing fire frequencies in other plant communities in the eastern United States. In wetter areas, dominated by *P. serotina* and *P. taeda* in the southern U.S., and *P. rigida* in New Jersey, the fire frequency is thought to be 25 to 50 years (Little, 1979; Fowells, 1965). Fire frequency in xeric forests of the New Jersey pine barrens is calculated to be 8 to 20 years (Boerner, 1981), and burning every three years was found to reduce shrub coverage and increase herbaceous cover (Reiners, 1965; Buell and Cantlon, 1953). *P. palustris* stands in the south, although not under natural fire regimes, seemed to burn every 3 to 10 years (Platt et al., 1987; Waldrop et al., 1987; Gilliam and Christensen, 1986).

P. palustris' unique population dynamics and reproductive biology place certain limitations on fire frequency. *P.*

palustris seedlings require two years without fire following germination, and then are fire resistant for the remaining three or four years of grass stage. When height growth begins, they are sensitive to fire for three or four years until the terminal bud reaches a height of two or three meters, at which point they are above ground fire height. Good seed years occur every five to seven years and seedlings require a recently burned (within one year) forest floor on which to germinate. *P. palustris* seedlings are extremely sensitive to shrub and hardwood competition and suffer severe mortality after about 10 years without fire (Croker and Boyer, 1975).

Since the Zuni Pine Barrens in Virginia contains species found in both northern and southern pine barrens and the geographic location is intermediate, it seems likely that the natural fire frequency should be intermediate between those found to the south and to the north, i.e. about every 6 to 12 years.

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APPENDIX 1: DETAILED RESULTS

Study 1

Overstory and Sapling Layers

In Barrens 1, overstory density was reduced from 15.8 /100 m^2 to 10.1 and the number of species sampled was reduced from 11 to 6 with *Ilex opaca, Oxydendron arborea, Q. velutina, Nyssa sylvatica and Sassafras albidum* being lost from the sample. Before the fire, *Q. laevis* had the greatest IV (28.3). This species, however, suffered the greatest mortality (91.7%) and *P. palustris,* which had the lowest mortality (10.3%), was found to have the highest IV (43.7) following the fire (App. Table 1). Results of one-tailed, paired T-tests showed that, from 1985 to 1986, *Q. laevis* decreased significantly ($p = .0011$). Between 1986 and 1989, no species changed significantly in number. A one-way Anova by species with difference between years as the variate showed a marked difference between species ($p = .0003$) for Diff86 with *Q. laevis* decreasing more than all other species. For Diff89 no significant difference between species was found.

In the sapling/large shrub layer, density was reduced from 13.3 /100 m^2 to 1.5 and the number of species sampled was reduced from 16 to 7 with *Amelanchier canadensis, Vaccinium corymbosum, Diospyros virginiana, Magnolia virginiana, N. sylvatica, O. arboreum, Q. velutina, S. albidum* and *I. opaca* being lost from the sample. As in the overstory, *Q. laevis* had the highest pre-fire IV (25.6) and the greatest mortality (97.0%). *P. palustris* had the lowest mortality (66.2%) and had the highest IV after the fire (30.3) (App. Table 2). One-tailed paired T-tests showed that, between 1985 and 1986, *P. palustris* ($p = .003$), *P. serotina* ($p = .0008$) and *Q. laevis* ($p = .0006$) decreased significantly. No species decreased between 1986 and 1989. A one-way Anova showed a strong difference between species for Diff86 ($p = .0048$). *Q. laevis* differed from *P. taeda*. No difference between species was found for Diff89.

In Barrens 2, overstory density was reduced from 9.0 /100 m^2 to 6.8 and the number of species sampled was reduced from four to three with *Q. laevis* being lost from the sample. In this area, *P. serotina* and *P. taeda* were strong pre-fire dominants (76% of the total IV) and remained so after the fire (App. Table 3). Paired one-tailed T-tests were unable to detect decreases for any species and a one-way Anova showed no difference between any species for Diff88 or Diff89.

Sapling/large shrub density was reduced from 16.2/100 m^2 to 1.5 and the number of species sampled was reduced from 12 to 2. Before the fire, *P. serotina* and *Q. laevis* had the highest IV's (27.7 and 16.0, respectively). Following the fire *P. serotina* and *P. taeda* were dominant and *Q. laevis* and *P. palustris* were lost from the sample (Table 4). Paired one-tailed T-tests showed that between 1986 and 1988 *P. serotina* ($p = .012$) and *Q. laevis* ($p = .0043$) decreased significantly but no species decreased between 1988 and 1989. A one-way Anova showed no difference between species for Diff88 or Diff89.

In Mesic Area 1, overstory density was reduced from 11.1 /100 m^2 to 5.9 and the number of species sampled was reduced from 12 to 11 with *Q. laevis* being lost from the sample. Before the fire, *P. serotina* and *P. taeda* had the highest IV's (47.3 and 20.7, respectively) and continued to do so following the fire even though they suffered the greatest mortality (54.2% and 46.2%). *A. rubrum,* which had the lowest mortality (20.0%), increased to third highest in IV (11.1) (App. Table 5). Paired one-tailed T-tests showed that *P. serotina* decreased significantly between 1985 and 1986 ($p = .0056$) and also between 1986 and 1989 ($p = .026$). A one-way Anova showed that differences between species exist for Diff86 ($p = .0035$). *P. serotina* decreased more than *A. rubrum.* No difference between species was found for Diff89.

Sapling/large shrub density was reduced from 36.8 /100 m^2 to 9.6 and the number of species sampled decreased from 15 to 11. Before the fire *V. corymbosum* and *A. canadensis* had the highest IV's (23.8 and 12.8, respectively). Following the fire *V. corymbosum* remained highest but *A. canadensis,* with the greatest mortality (93.3%), decreased to fifth highest IV

(5.5) while *A. rubrum,* with the lowest mortality (57.8%), became second most important (12.0) (App. Table 6). Paired, one-tailed T-tests showed that six species had decreased significantly between 1985 and 1986: *A. canadensis* ($p = .0044$), *A. rubrum* ($p = .0041$), *P. taeda* ($p = .0033$), *M. virginiana* ($p = .0024$), *P. serotina* ($p = .0008$), and *V. corymbosum* ($p = .0002$). No species decreased between 1986 and 1989. A one-way Anova showed that a marked difference between species existed for Diff86 ($p = .0001$). *V. corymbosum* and *A. canadensis* differed from *A. rubrum, N. sylvatica, I. opaca* and *P. taeda*. No difference between species was found for Diff89.

In Mesic Area 2, overstory density was reduced from 13.7 /100 m^2 to 11.1 (19.1% mortality: 10.1% in 1988 and 9.0% in 1989). The number of species sampled decreased from 14 to 12 with *Q. laevis* and *S. albidum* being lost from the sample. Before and after the fire, *P. taeda* and *P. serotina had the* highest IV's (26.8 and 21.9, respectively) (App. Table 7). Paired, one-tailed T-tests showed that *P. taeda* decreased significantly between 1986 and 1988 ($p = .039$) and also between 1988 and 1989 ($p = .040$). *A. rubrum* decreased between 1988 and 1989 ($p = .040$). A one-way Anova showed no difference between species for Diff88. For Diff89 a significant difference between species was found ($p = .0044$). *A. rubrum* decreased more than *P. serotina*, *N. sylvatica* and *Liquidambar styraciflua*.

In the sapling/large shrub layer, density was reduced from 22.1/100 m² to 4.9 and the number of species sampled decreased from 20 to 12. Before the fire, *V. corymbosum*, *O. arboreum* and *N. sylvatica* had the highest IV's (13.9, 11.5 and 10.8, respectively), but following the fire, *N. sylvatica* and *O. arboreum* had the highest IV's and *V. corymbosum*, which suffered the greatest mortality (80.5%), decreased to fourth highest in importance (8.4) (Table 8). Paired, one-tailed T-tests showed that six species decreased between 1986 and 1988: *A. rubrum* ($p = .029$), *I. opaca* ($p = .033$), *V. corymbosum* ($p = .022$), *P. taeda* ($p = .016$), *O. arboreum* ($p = .012$) and *M. virginiana* ($p = .008$). *A. rubrum* also decreased between 1988 and 1989 ($p = .0059$). A one-way Anova showed that no differences between species existed for Diff88 or Diff89.

In the Swamp, overstory density decreased from 7.8/100 m² to 2.8 and the number of species sampled decreased from eight to seven with the loss of *O. arboreum*. Before the fire, *A. rubrum* and *P. serotina* had the highest IV's (48.9 and 19.5, respectively). After the fire, *P. serotina* had the highest IV (27.2) while *A. rubrum* suffered the greatest mortality of any surviving species (78.6%) (App. Table 9). Paired, one-tailed T-tests showed that *A. rubrum* decreased between 1985 and 1986 ($p = .023$) and no species decreased between 1986 and 1989. A one-way Anova showed that no differences between species existed for Diff86 or for Diff89.

In the sapling/large shrub layer, density was reduced from 31.8 /100 m^2 to 3.5 and the number of species sampled decreased from 11 to 4. Before and after the fire, *V. corymbosum*, *A. canadensis* and *A. rubrum* had the highest IV's (31.6, 19.2 and 16.9, respectively) (App. Table 10). Paired, one-tailed T-tests showed that *A. canadensis* ($p = .031$), *M. virginiana* ($p = .0078$) and *V. corymbosum* ($p = .0066$) decreased between 1985 and 1986. No species decreased between 1986 and 1989. A one-way Anova showed that no differences between species existed for Diff86 or for Diff89.

Understory

In Barrens 1, understory density increased from 15.1 /m^2 to 104.8 and the number of species sampled increased from 9 to 22. One species, *I. glabra*, was lost from the sample. In addition, four species (*V. crassifolium, Amphicarpa bracteata, Aristida virgata* and *Lechea spp.*) were encountered but did not occur in sample plots. Before the fire, the numerically dominant species were *Gaylussacia baccata, Kalmia angustifolia, Gaultheria procumbens* and *Pteridium aquilinum*. After the fire, *G. baccata* and *K. angustifolia* remained dominant. *G. frondosa* and *Smilax glauca increased,* respectively, to third and fourth highest IV. *P. aquilinum* remained the most numerous herbaceous species and tree regeneration was numerically dominated by *P. taeda, S. albidum* and *Q. laevis* (App. Table 11). Paired, two-tailed T-tests showed that between 1985 and 1986, *K. angustifolia* ($p = .026$), *S. glauca* ($p = .015$) and *G. baccata* ($p = .0004$) increased. Between 1986 and 1988, *V. vaccilans* ($p = .029$) and *G. frondosa* ($p = .013$) increased. A repeated measures Anova showed that there was a difference in number of individuals due to time (Wilk's Lambda, $p = .0001$) and there was interaction between species and time (Wilk's Lambda, $p = .003$), showing that species behaved differently from each other. Contrast statements for time showed that 1985 differed from 1986 ($p = .0001$). Contrast statements for species showed that *G. baccata* ($p = .0012$) and *K. angustifolia* ($p = .0006$) increased more than the mean. A Canononical Discriminant Analysis found a significant separation due to time between 1985 and 1986-1988 (Wilk's Lambda, $p = .0017$). Only the first canononical coefficient was significant. Paired T-tests on values for total herbaceous, total shrub and total tree density showed that between 1985 and 1986 a significant difference in shrub density ($p = .0003$) existed. No significant differences existed between 1986 and 1988.

In Barrens 2, understory density increased from $39.0/m^2$ to 146.7 and the number of species sampled increased from 10 to 21. Two species, *S. albidum* and *Q. laevis*, were lost from the sample. Before the fire, *G. dumosa, G. procumbens, K. angustifoliia* and *G. frondosa* had the highest IV's. After the fire, the most important species were *G. procumbens, V.*

tenellum, G. dumosa and *K. angustifolia*. *P. aquilinum* and *Carex nigromarginata* were the most abundant herbaceous species and tree regeneration was numerically dominated by *S. albidum* and *P. taeda* (App. Table 12).

Paired T-tests showed that no single species differed in number between 1986 and 1988 or between 1988 and 1989. A repeated measures Anova found a significant difference in number of individuals due to time (Wilk's Lambda, $p = .029$). There was no significant interaction between time and species, i.e. species did not differ in their response to time. Contrast statements on time showed that 1986 significantly differed from 1988 ($p = .011$). Contrast statements on species showed that no species differed from the mean in density. The results of Canononical Discriminant Analysis were not significant. Paired T-tests on total herbaceous, total shrub and total tree density showed that a significant difference in shrub density existed between 1986 and 1988 ($p = .009$).

In Mesic Area 1, understory density increased from $8.5/m^2$ to 90.3 and the number of species sampled increased from 15 to 42. In addition, four new species (*Sarracenia purpurea, Amianthium muscaetoxicum, Habeneria blephariglottiis* and *Baccharis halmifolia*) were observed although not present in the sample plots. Before the fire, *V. corymbosum, G. frondosa, Clethra alnifolia* and *Pyrus melanocarpa* had the highest IV's. Following the fire, *G. frondosa* remained high in importance and *P. aquilinum, A. rubrum* and *S. rotundifolia* increased, respectively, to first, second and fourth highest IV. *P. aquilinum, Erechtites hieracifolia* and *Hexastylis virginica* were the most abundant herbaceous species and *A. rubrum, N. sylvatica* and *P. serotina had* the most numerous tree regeneration (App. Table 13).

The results of paired T-tests showed that between 1985 and 1986, *P. aquilinum* ($p = .032$) and *S. glauca* ($p = .024$) increased in number and between 1986 and 1988, six species (*P. aquilinum* ($p = .031$), *S. glauca* ($p = .009$), *A. rubrum* ($p = .012$), *G. frondosa* ($p = .012$), *Leucothoe racemosa* ($p = .011$) and *E. hieracifolia* ($p = .034$)) similarly increased. A repeated measures Anova showed a significant effect due to time (Wilk's Lambda, $p =.0001$) and interaction between time and species was significant (Wilk's Lambda, $p = .0004$). Contrast statements on time found that 1985 differed from 1986 ($p = .0001$) and 1986 differed from 1988 ($p = .0001$). Contrast statements on species for Diff86 were not significant. For Diff88, *G. frondosa* ($p = .0001$), *A. rubrum* ($p = .0004$) and *P. aquilinum* ($p = .0004$) differed from the mean in their response to time (Table 16). A Canononical Discriminant Analysis showed a significant separation due to time between 1985-1986 and 1988 (Wilk's Lambda, $p = .0001$). Only the first canononical coefficient was significant. Paired T-tests on total herbaceous, total shrub and total tree densities showed that between 1985 and 1986, significant differences in herbaceous density ($p = .008$) and shrub density ($p = .032$) existed. Herbaceous density ($p = .014$) and shrub density ($p = .004$) also differed between 1986 and 1988.

In Mesic Area 2, understory density increased from $10.0/m^2$ to 32.6 and the number of species sampled increased from 16 to 29. Five species were lost from the sample: *Carya glabra, H. virginica, I. glabra, Q. falcata* and *Vitis rotundifolia*. Before the fire, *V. corymbosum, S. glauca, C. alnifolia* and *P. aquilinum* had the highest IV's. After the fire, *S. glauca* and *C. alnifolia* remained high in importance and *Rhododendron nudiflorum* and *S. rotundifolia* increased to second and third highest, respectively. *P. aquilinum, H. virginica* and *Woodwardia virginica* were the most numerous herbaceous species and *A. rubrum, S. albidum* and *P. taeda* had the most abundant tree regeneration (App. Table 14).

Paired T-tests showed that, between 1986 and 1988, *A. rubrum* ($p = .017$) and *S. albidum* ($p = .032$) increased significantly but between 1988 and 1989, *S. albidum* ($p = .042$) decreased. A repeated measures Anova showed a significant effect due to time (Wilk's Lambda, $p = .0001$). Interaction between time and species was significant (Wilk's Lambda, $p = .012$). Contrast statements on time showed that 1986 differed from 1988 ($p = .0003$). Contrast statements on species showed that *R. nudiflorum* ($p = .0047$) differed from the mean in change in number over time. A Canononical Discriminant Analysis was not significant. Paired T-tests on total herbaceous, total shrub and total tree densities were not significant.

In the Swamp, understory density increased from $5.2/m^2$ to 31.5 and the number of species sampled increased from 6 to 24. One species, *M. virginiana*, was lost from the sample. Before the fire, the species with the highest IV's were *C. alnifolia, V. corymbosum, M. virginiana* and *G. procumbens*. Following the fire, *C. alnifolia* and *V. corymbosum* remained high in importance and *A. rubrum* and *P. aquilinum* increased to first and second highest, respectively. The most abundant herbaceous species were *P. aquilinum, Mitchella repens* and *H. virginica* and tree regeneration was numerically dominated by *A. rubrum* and *P. serotina* (App. Table 15).

Paired T-tests found that no single species differed in number between years. A repeated measures Anova showed a significant effect due to time (Wilk's Lambda, P = .0027). Interaction between time and species was significant (Wilk's Lambda, p = .0024). Contrast statements on time showed that 1985 differed from 1986 (p = .001). Contrast statements on species found no species to be different from the mean for Diff86. Between 1986 and 1988, *A. rubrum* (p = .0006) was significantly different from the mean in change over time. A Canononical Discriminant Analysis was not significant. Paired

T-tests on total herbaceous, total shrub, and total tree densities were not significant.

Unpaired, two-tailed T-tests showed that in Barrens 1, no differences between amounts of sexual and vegetative regeneration could be found for *S. albidum, S. glauca* or *V. vaccilans*. In Barrens 2, *S. albidum* showed no difference between amounts of sexual and vegetative regeneration. In Mesic Area 1, *P. melanocarpa, S. glauca* and *S. rotundifolia* showed no differences. *A. rubrum*, however, reproduced more by seed than by vegetative sprout ($p = .015$). *C. alnifolia* ($p = .011$), *L. racemosa* ($p = .021$) and *I. glabra* ($p = .040$) regenerated predominantly by vegetative means. In Mesic Area 2, *S. albidum, A. rubrum, C. alnifolia, R. nudiflorum, S. glauca* and *S. rotundifolia* showed no differences between amounts of sexual and vegetative reproduction. In the Swamp, *A. rubrum, M. virginiana* and *M. repens* showed no differences. In all areas, however, the majority of the species capable of vegetative regeneration failed to reproduce by seed (App. Table 16).

<u>Study 2</u>

<u>Understory Population Dynamics</u>

In the burned, not logged treatment, the most numerous tree seedling species in 1988 were *Q. laevis, S. albidum* and *Diospyros virginiana*. In 1989, *Q. laevis, P. taeda* and *S.*

albidum were most abundant. The most abundant herbaceous species in 1988 were *C. nigromarginata, E. hieracifolium* and *C. bellidifolius*. In 1989, *C. nigromarginata, P. lanuginosum* and *Euphorbia ipecacuanhae* dominated (App. Table 17).

Paired T-tests showed that between 1988 and 1989, *P. taeda* increased significantly (p = .009). Between 1989 and 1991, *D. virginiana* (p = .030), *S. albidum* (p = .025) and *P. taeda* (p = .008) decreased while *Q. nigra* (p = .015) increased. A repeated measures Anova showed a significant difference due to time (Wilk's Lambda, p = .0001) and a significant interaction between time and species (Wilk's Lambda, p = .0001). Contrast techniques showed that *Q. nigra* (p = .0001), *P. taeda* (p = .002) and *C. nigromarginata* (p = .005) differed from the mean in change in number over time. A one-way Anova showed a significant difference between species for Diff91 (p = .0001). *P. lanuginosum* differed from all other species. Canononical Discriminant Analysis showed a significant separation between years (Wilk's Lambda, p = .015).

In the burned and logged treatment, the most numerous tree seedling species in both 1988 and 1989 were *Q. laevis, S. albidum* and *P. taeda*. In 1988, the most abundant herbaceous species were *C. nigromarginata, Cnidoscolus stimulosus* and *E. hieracifolia*. *C. nigromarginata, Erigeron canadensis* and *E. ipecacuanhae* dominated in 1989 (App. Table 18).

Paired T-tests showed that *P. taeda* (p = .010), *Q. laevis* (p = .017) and *Q. nigra* (p = .026) increased between 1988 and 1989. Between 1989 and 1991, *Q. laevis* (p = .013) decreased and *P. lanuginosum* (p = .016) increased. A repeated measures Anova showed a significant effect due to time (Wilk's Lambda, p = .0001) and a significant interaction between time and species (Wilk's Lambda, p = .0001). Contrast techniques showed that *C. nigromarginata* (p = .0001) differed from the mean in change in number over time. A one-way Anova showed a significant difference between species for Diff91 (p = .0002). *P. lanuginosum* differed from *E. hieracifolia, Q. laevis* and *E. canadensis*. A Canononical Discriminant Analysis showed a significant separation due to time (Wilk's Lambda, p = .0002).

In the mechanically cleared and logged treatment, the most numerous tree seedling species in 1988 and 1989 were *Q. laevis, Q. nigra* and *S. albidum*. In 1988, the most abundant herbaceous species were *Polygonella polygama, C. bellidifolius* and *Pyxidanthera barbulata*. *C. nigromarginata, P. polygama* and *P. lanuginosum* were the most numerous in 1989 (App. Table 19).

Paired T-tests showed that between 1988 and 1989, *P. polygama* (p = .008), *P. barbulata* (p = .008), *S. albidum* (p = .029) and *Q. nigra* (p = .035) increased. Between 1989 and 1991, *S. albidum* (p = .012), *P. taeda* (p = .033) and *Q. laevis* (p = .033) decreased. A repeated measures Anova showed a significant difference due to time (Wilk's Lambda, p = .0001) and a significant interaction between time and species (Wilk's Lambda, p = .0001). Contrast statements showed that *C. nigromarginata* (p = .0001) differed from the mean in change in number over time. A one-way Anova showed a significant difference between species for Diff91 (p = .0001). *P. polygama* differed from all species. A Canononical Discriminant Analysis showed a significant separation between years (Wilk's Lambda, p = .0008).

In the mechanically cleared, not logged treatment, the most abundant tree seedling species in 1988 were *S. albidum, Q. nigra* and *Q. laevis*. In 1989, *Q. nigra, S. albidum* and *P. taeda* were the most numerous. The numerically dominant herbaceous species in 1988 were *P. aquilinum, P. polygama* and *C. nigromarginata* while *P. aquilinum, C. nigromarginata* and *Solidago odora* dominated in 1989 (App. Table 20).

The results of Paired T-tests on numbers of individuals by species between years were not significant. A repeated measures Anova showed a significant effect due to time (Wilk's Lambda, p = .0001) and a significant interaction between time and species (Wilk's Lambda, p = .0001). Contrast techniques showed that *C. nigromarginata* (p = .0001) and *S. odora* (p = .0001) differed from the mean in change in number over time. A Canononical Discriminant Analysis showed a significant separation between years (Wilk's Lambda, p = .0001).

In the control treatment, the most numerous tree seedling species in 1988 were *Q. nigra, Q. laevis* and *S. albidum*. *Q. nigra, S. albidum* and *P. taeda* were the most abundant in 1989. In 1988, the most abundant herbaceous species were *P. aquilinum, C. nigromarginata* and *C. bellidifolius*. The most numerous herbaceous species in 1989 were *P. aquilinum, C. nigromarginata* and *S. odora* (App. Table 21).

Paired T-tests showed that between 1988 and 1989, *C. nigromarginata* ($p = .004$), *Q. nigra* ($p = .016$) and *S. albidum* ($p = .033$) increased. Between 1989 and 1991, *S. albidum* ($p = .020$) decreased and *P. lanuginosum* ($p = .042$) increased. A repeated measures Anova found a significant effect due to time (Wilk's Lambda, $p = .0001$) and a significant interaction between time and species (Wilk's Lambda, $p = .0001$). Contrast techniques showed that *C. nigromarginata* ($p = .0001$) and *S. odora* ($p = .0044$), which increased, and *Q. laevis* ($p = .0014$), which remained stable, differed from the mean in change in number over time. A one-way Anova showed a significant difference between species for Diff91 ($p = .004$). *P. lanuginosum* differed from *Q. nigra, S. albidum* and *P. taeda*. A Canononical Discriminant Analysis showed a significant separation between years (Wilk's Lambda, $p = .0001$).

A doubly multivariate repeated measures Anova with manipulation type (five treatments) as the treatment, and time and species as the dependent variables showed a significant effect due to treatment (p = .0001). Contrast techniques showed that burned, not logged (p = .0001); burned and logged (p = .0001); and mechanically cleared, logged (p = .0012) differed from the mean. Mechanically cleared, not logged and control did not differ from the mean in change in number over time. Contrast techniques on species showed that *C. nigromarginata* and *P. lanuginosum* did not differ between treatments. *P. taeda* (p = .0001), *Q. laevis* (p = .0001), *Q. nigra* (p = .0039) and *S. albidum* (p = .0045) behaved differently in different treatments. The effect of time was also significant (p = .0001). Contrast techniques on time showed that *C. nigromarginata* (p = .0001), *P. lanuginosum* (p = .0022), *P. taeda* (p = .0001), *Q. nigra* (p = .0001) and *S. albidum* (p = .027) differed significantly over time. Interaction between time and treatment was not significant.

APPENDIX 2: TABLES

A2-Table 1. Overstory composition of Barrens 1. Density, standard error, frequency, dominance, importance value and mortality. n=10

11 spp.	1985 (Pre-burn)					1986						1989					6 spp.	
Species	Density (Ind/100m2)	SE	Frequency	Dominance (m2/ha)	IV	Density	SE	Frequency	Dominance	IV	Mortality (%)	Density	SE	Frequency	Dominance	IV	Mortality	Total Mort
Q.laevis	4.50	.7	.87	9.18	28.3	.4	.3	.30	0	5.4	88.9	.3	.3	.20	0	3.9	2.9	91.8
P.palustris	4.87	1.7	.75	6.88	25.2	5.5	1.5	.70	8.0	43.2	10.3	5.4	1.5	.70	9.2	43.7	0	10.3
P.taeda	3.12	.9	.75	5.16	19.5	2.8	.8	.80	5.7	31.4	24.0	2.6	.8	.80	6.9	31.9	8.0	32.0
P.serotina	2.25	1.2	.50	5.74	16.1	1.6	1.5	.40	2.8	16.1	11.1	1.6	1.5	.40	3.2	16.6	0	11.1
N.sylvatica	.37	.5	.25	.23	3.3	0	0	0	0	0		0	0	0	0	0		
I.opaca	.25	0	.12	.23	1.9	0	0	0	0	0		0	0	0	0	0		
O.arboreum	.12	0	.12	.23	1.7	0	0	0	0	0		0	0	0	0	0		
Q.falcata	.12	0	.12	.23	1.7	.1	0	.10	.2	2.2		.1	0	.10	.2	2.2		
Q.velutina	.12	0	.12	0	1.3	0	0	0	0	0		0	0	0	0	0		
S.albidum	.12	0	.12	0	1.3	0	0	0	0	0		0	0	0	0	0		
Q.nigra	0	0	0	0	0	.1	0	.10	.2	1.7		.1	0	.10	.2	1.8		
Total	15.8			27.8		10.5			16.7		33.7	10.1			19.5		2.5	36.2

A2-Table 2. Sapling/large shrub layer composition of Barrens 1. Density, standard error, frequency, importance value and mortality. n=10

16 spp.	1985 (Pre-burn)				1986					1989				7 spp.	
Species	Density (Ind/100m2)	SE	Frequency	IV	Density	SE	Frequency	IV	Mortality (%)	Density	SE	Frequency	IV	Mortality	Total Mort
Q.laevis	4.22	.78	.78	25.6	.30	.20	.30	19.5	91.1	.10	.10	.10	7.9	5.9	97.0
P.taeda	1.33	.61	.67	13.4	.40	.30	.30	22.1	71.8	.40	.30	.30	27.0	0	71.8
P.serotina	1.55	.87	.44	11.4	.30	.30	.10	11.8	75.8	.20	.20	.10	11.2	8.1	83.9
P.palustris	1.11	.71	.44	9.7	.50	.45	.30	24.7	66.2	.50	.45	.30	30.3	0	66.2
N.sylvatica	.78	.50	.22	5.7	0	0	0	0		0	0	0	0		
S.albidum	.55	.50	.22	4.8	0	0	0	0		0	0	0	0		
V.corymbosum	.78	0	.11	4.3	0	0	0	0		0	0	0	0		
D.virginiana	.33	.33	.22	4.0	0	0	0	0		0	0	0	0		
A.canadensis	.67	0	.11	3.9	0	0	0	0		0	0	0	0		
M.virginiana	.55	0	.11	3.5	0	0	0	0		0	0	0	0		
Q.margaretta	.44	0	.11	3.1	.20	0	.10	9.1		.10	0	.10	7.9		
I.opaca	.33	0	.11	2.7	0	0	0	0		0	0	0	0		
C.pallida	.33	0	.11	2.7	.10	0	.10	6.5		.10	0	.10	7.9		
O.arboreum	.11	0	.11	1.8	0	0	0	0		0	0	0	0		
P.echinata	.11	0	.11	1.8	.10	0	.10	6.5		.10	0	.10	7.9		
Q.velutina	.11	0	.11	1.8	0	0	0	0		0	0	0	0		
Total	13.3				1.9				85.7	1.5				3.0	88.7

A2-Table 3. Overstory composition of Barrens 2. n=6

4 spp.	1986 (Pre-burn)					1988						1989			3 spp.			
Species	Density (Ind/100m2)	SE	Frequency	Dominance (m2/ha)	IV	Density	SE	Frequency	Dominance	IV	Mortality (%)	Density	SE	Frequency	Dominance	IV	Mortality	Total Mort
P.serotina	4.00	1.1	1.0	11.0	45.9	2.7	1.4	.67	8.3	42.6	33.2	2.5	1.4	.67	8.3	42.5	4.2	37.5
P.taeda	3.20	3.2	.4	7.8	29.2	3.3	3.3	.50	7.8	41.1	0	3.3	3.3	.50	7.8	41.9	0	0
P.palustris	1.20	0	.4	3.2	15.2	1.0	0	.33	2.3	16.3	16.7	1.0	0	.33	1.8	15.6	0	16.7
Q.laevis	.60	.5	.4	.9	9.6	0	0	0	0	0	100	0	0	0	0	0	0	100
Total	9.0			22.9		7.0			18.4		22.2	6.8			17.9		1.9	24.1

A2-Table 4. Sapling/large shrub layer composition of Barrens 2. n=6

12 spp.	1986 (Pre-burn)				1988					1989					2 spp.
Species	Density (Ind/100m2)	SE	Frequency	IV	Density	SE	Frequency	IV	Mortality (%)	Density	SE	Frequency	IV	Mortality	Total Mort
P.serotina	5.6	1.3	1.0	27.7	1.2	.9	.50	43.2	79.1	.67	.37	.50	52.5	4.3	88.0
Q.laevis	1.8	.4	1.0	16.0	.2	.2	.17	10.4	88.9	0	0	0	0	11.1	100
P.taeda	2.8	2.8	.4	12.8	1.2	1.2	.33	36.0	78.6	.83	.83	.33	47.5	7.1	85.7
P.palustris	1.0	.7	.6	9.4	.2	.2	.17	10.4	83.0	0	0	0	0	17.0	100
I.opaca	1.2	1.0	.4	7.8	0	0	0	0		0	0	0	0		
N.sylvatica	1.6	0	.2	7.1	0	0	0	0		0	0	0	0		
A.rubrum	.8	0	.2	4.6	0	0	0	0		0	0	0	0		
A.canadensis	.6	0	.2	4.0	0	0	0	0		0	0	0	0		
C.glabra	.2	0	.2	2.7	0	0	0	0		0	0	0	0		
M.cerifera	.2	0	.2	2.7	0	0	0	0		0	0	0	0		
O.arboreum	.2	0	.2	2.7	0	0	0	0		0	0	0	0		
Q.nigra	.2	0	.2	2.7	0	0	0	0		0	0	0	0		
Total	16.2				2.7				83.5	1.5				7.3	90.7

A2-Table 5. Overstory composition of Mesic Area 1. n=12

12 spp.	1985 (Pre-burn)					1986						1989 11 spp.						
Species	Density (Ind/100m2)	SE	Frequency	Dominance (m2/ha)	IV	Density	SE	Frequency	Dominance	IV	Mortality (%)	Density	SE	Frequency	Dominance	IV	Mortality	Total Mort
P.serotina	6.73	1.2	.82	15.6	47.3	3.5	1.0	.75	8.2	44.6	48.0	3.1	.97	.75	9.4	44.4	6.2	54.2
P.taeda	2.64	1.7	.64	4.8	20.7	1.6	.6	.58	4.4	24.8	40.1	1.4	.43	.58	4.8	24.5	6.1	46.2
N.sylvatica	.36	.2	.36	1.9	7.3	.3	.2	.25	.8	6.2	30.6	.3	.24	.25	.8	6.1	0	30.6
A.rubrum	.45	.4	.27	2.3	7.0	.5	.3	.33	1.7	10.5	20.0	.5	.29	.33	2.1	11.1	0	20.0
Q.nigra	.18	0	.18	.4	3.1	.1	.1	.08	.2	1.8		.1	.08	.08	.2	1.9		
A.canadensis	.09	0	.09	1.5	2.9	.1	0	.08	0	1.5		.1	0	.08	0	1.5		
O.arboreum	.18	0	.09	.6	2.3	.2	0	.08	.6	3.1		.2	0	.17	.6	3.1		
M.virginiana	.09	0	.09	.8	2.2	.1	0	.08	0	1.5		.1	0	.08	0	1.5		
I.opaca	.09	0	.09	.6	2.0	.1	0	.08	.4	6.7		.1	0	.08	.4	2.2		
Q.laevis	.09	0	.09	.6	2.0	0	0	0	0	0		0	0	0	0	0		
Q.velutina	.09	0	.09	.2	1.5	.1	0	.08	.2	1.8		.1	0	.08	.2	1.9		
Q.falcata	.09	0	.09	.2	1.5	.1	0	.08	.2	1.8		.1	0	.08	.2	1.9		
Total	11.1			29.6		6.5			16.6		41.5	5.9			18.5		5.2	46.7

A2-Table 6. Sapling/large shrub layer composition of Mesic Area 1. n=12

15 spp.	1985 (Pre-burn)				1986					1989 11 spp.					
Species	Density (Ind/100m2)	SE	Frequency	IV	Density	SE	Frequency	IV	Mortality (%)	Density	SE	Frequency	IV	Mortality	Total Mort
V.corymbosum	12.7	3.6	.82	23.8	5.0	2.6	.67	33.0	60.7	4.7	2.6	.58	34.3	2.6	63.3
A.canadensis	6.27	2.4	.54	12.8	.4	.4	.25	5.5	93.3	.4	.42	.25	6.5	0	93.3
P.serotina	4.09	1.1	.73	11.3	.6	.3	.42	8.7	85.8	.4	.34	.25	6.5	3.9	89.7
M.virginiana	4.00	1.0	.73	11.2	.8	.6	.25	7.5	79.3	.7	.64	.25	8.2	2.0	81.3
N.sylvatica	2.64	.8	.82	10.1	1.0	.4	.50	11.9	62.1	.8	.44	.42	11.6	6.4	68.6
A.rubrum	2.18	.6	.64	8.0	1.0	.4	.50	11.9		.9	.46	.42	12.0		
P.taeda	1.45	.3	.54	6.2	.3	.3	.25	5.1		.2	.17	.08	2.3		
I.opaca	1.09	.7	.54	5.8	.5	.5	.25	5.9		.4	.40	.25	6.5		
O.arboreum	.64	.3	.27	3.0	.3	.3	.25	5.1		.3	.33	.25	6.0		
S.albidum	.45	.3	.27	2.7	0	0	0	0		0	0	0	0		
I.verticillata	.36	0	.09	1.2	.3	0	.08	2.7		.3	0	.08	3.1		
R.nudiflorum	.36	0	.09	1.2	.3	0	.08	2.7		.3	0	.08	3.1		
M.cerifera	.18	0	.09	1.0	0	0	0	0		0	0	0	0		
Q.laevis	.27	0	.09	1.0	0	0	0	0		0	0	0	0		
Q.nigra	.09	0	.09	0.8	0	0	0	0		0	0	0	0		
Total	36.8				10.6				71.1	9.6				2.9	73.9

A2-Table 7. Overstory composition of Mesic Area 2. n=9

14 spp.	1986 (Pre-burn)					1988						1989						12 spp.
Species	Density (Ind/100m2)	SE	Frequency	Dominance (m2/ha)	IV	Density	SE	Frequency	Dominance	IV	Mortality (%)	Density	SE	Frequency	Dominance	IV	Mortality	Total Mort
P.taeda	4.0	.7	.9	11.2	26.8	3.8	.4	.8	12.6	28.4	9.5	3.4	.35	.89	12.3	29.2	6.2	15.7
P.serotina	3.4	1.0	.8	8.6	21.9	2.6	.6	.6	9.7	20.8	24.0	2.6	.65	.67	10.0	22.7	0	24.0
A.rubrum	1.6	1.2	.4	3.1	9.6	1.7	.8	.4	3.7	11.1	0	1.1	.64	.44	2.9	9.5	38.3	38.3
Q.nigra	1.0	.4	.5	2.3	8.1	.9	.4	.4	2.3	7.7	.1	.7	.64	.33	1.7	6.2	.2	.3
N.sylvatica	1.0	.7	.5	1.4	7.3	1.0	.6	.5	1.4	8.0		1.0	.58	.55	1.2	8.3		
L.styraciflua	.8	.5	.5	.9	6.1	.9	.4	.5	.9	7.2		.9	.40	.55	.9	7.6		
O.arboreum	.4	.4	.3	2.3	4.9	.3	.3	.2	1.7	4.1		.3	.33	.22	1.4	4.1		
Q.alba	.5	.5	.3	1.7	4.6	.4	.4	.2	1.4	4.1		.4	.44	.22	1.4	4.4		
Q.velutina	.4	.4	.3	.6	3.2	.3	.3	.2	.9	3.3		.3	.33	.22	.9	3.5		
Q.laevis	.3	0	.1	.3	1.7	0	0	0	0	0		0	0	0	0	0		
Q.falcata	.1	0	.1	.6	1.7	.1	0	.1	.6	1.6		.1	0	.11	.6	1.7		
C.glabra	.1	0	.1	.3	1.4	.1	0	.1	.3	1.4		.1	0	.11	.3	1.4		
L.tulipifera	.1	0	.1	.3	1.4	.1	0	.1	.3	1.4		.1	0	.11	.3	1.4		
S.albidum	.1	0	.1	0	1.1	.1	0	.1	0	1.1		0	0	0	0	0		
Total	13.7			33.6		12.3			35.8		10.1	11.1			33.8		9.0	19.0

A2-Table 8. Sapling/large shrub layer composition of Mesic Area 2. n=9

20 spp.	1986 (Pre-burn)				1988					1989					12 spp.
Species	Density (Ind/100m2)	SE	Frequency	IV	Density	SE	Frequency	IV	Mortality (%)	Density	SE	Frequency	IV	Mortality	Total Mort
V.corymbosum	4.00	2.3	.75	13.9	1.0	1.0	.22	8.4	75.0	.8	.78	.11	10.0	5.5	80.5
O.arboreum	2.62	.6	.87	11.5	1.1	.4	.78	15.8	61.8	.7	.25	.55	17.6	12.6	74.4
N.sylvatica	3.00	1.6	.62	10.8	2.0	1.5	.55	17.9	29.3	1.0	.67	.44	18.7	37.3	66.7
A.rubrum	2.50	.9	.75	10.5	1.9	.6	.67	18.9	35.2	.9	.55	.33	15.4	40.0	75.2
L.styraciflua	1.37	.6	.62	7.1	.7	.7	.33	7.9		.4	.44	.22	8.8		
I.opaca	1.25	.9	.50	6.1	.2	.2	.11	2.6		0	0	0	0		
M.virginiana	1.25	.3	.62	6.8	.2	.2	.22	4.0		.1	.11	.11	3.3		
P.taeda	.87	.2	.62	5.9	.1	.1	.11	2.0		0	0	0	0		
M.cerifera	1.00	.9	.37	4.6	0	0	0	0		0	0	0	0		
Q.nigra	.87	.5	.25	3.6	.4	0	.22	5.2		.3	.33	.22	7.6		
P.serotina	.50	.3	.37	3.5	.1	.1	.11	2.0		0	0	0	0		
S.albidum	.37	.4	.25	2.5	.1	.1	.11	2.0		0	0	0	0		
Q.alba	.25	0	.25	2.2	0	0	0	0		0	0	0	0		
Q.velutina	.25	0	.25	2.2	.2	0	.22	3.9		.1	.11	.11	3.3		
Q.margaretta	.50	0	.12	1.9	.4	0	.11	3.9		.3	0	.11	5.4		
D.virginiana	.37	0	.12	1.6	.1	0	.11	2.0		.1	0	.11	3.3		
P.borbonia	.25	0	.12	1.3	.1	0	.11	2.0		.1	0	.11	3.3		
Q.falcata	.12	0	.12	1.0	.1	0	.11	2.0		.1	0	.11	3.3		
A.canadensis	.25	0	.12	1.3	0	0	0	0		0	0	0	0		
S.tinctoria	.50	0	.12	1.9	0	0	0	0		0	0	0	0		
Total	22.1				8.9				59.8	5.0				17.6	77.4

A2-Table 9. Overstory composition of the Swamp. n=6

8 spp.	1985 (Pre-burn)					1986						1989 7 spp.						
Species	Density (Ind/100m2)	SE	Frequency	Dominance (m2/ha)	IV	Density	SE	Frequency	Dominance	IV	Mortality (%)	Density	SE	Frequency	Dominance	IV	Mortality	Total Mort
A.rubrum	4.67	1.1	1.0	14.9	48.9	1.0	.82	.33	.8	22.2	78.6	1.0	.82	.33	.8	24.4	0	78.6
P.serotina	1.33	1.2	.5	6.9	19.5	.7	.67	.33	2.3	27.2	49.6	.7	.67	.33	2.3	24.9	0	49.6
P.taeda	.50	0	.5	1.9	9.8	.3	.33	.33	.8	14.3	34.0	.3	.33	.33	.8	14.3	0	34.0
S.albidum	.50	.5	.3	.8	6.6	.2	.17	.17	.4	7.3	66.0	.2	.17	.17	.4	7.3	0	66.0
I.opaca	.33	0	.3	.4	5.3	.3	0	.33	.4	12.1		.3	0	.33	.4	12.1		
N.sylvatica	.17	0	.2	1.1	4.0	.2	0	.17	.4	7.3		.2	0	.17	.4	7.3		
M.virginiana	.17	0	.2	.8	3.5	.2	0	.17	.8	9.5		.2	0	.17	.8	9.5		
O.arboreum	.17	0	.2	0	2.5	0	0	0	0	0		0	0	0	0	0		
Total	7.8			26.8		2.8			5.7		63.8	2.8			5.7		0	63.8

A2-Table 10. Sapling/large shrub layer composition of the Swamp. n=6

11 spp.	1985 (Pre-burn)				1986					1989			4 spp.		
Species	Density (Ind/100m2)	SE	Frequency	IV	Density	SE	Frequency	IV	Mortality (%)	Density	SE	Frequency	IV	Mortality	Total Mort
V.corymbosum	12.8	3.5	1.0	31.6	1.3	1.0	.33	31.8	89.6	1.2	.8	.50	38.0	1.2	90.9
A.canadensis	7.3	4.6	.7	19.2	1.2	1.2	.22	24.5	84.0	1.0	1.0	.17	21.6	2.3	86.4
A.rubrum	5.8	5.5	.7	16.9	1.0	1.0	.22	22.5	82.8	1.0	1.0	.33	28.4	0	82.8
M.virginiana	3.5	1.5	.7	13.2	.7	.7	.11	13.2	80.9	.3	.3	.17	12.0	9.7	90.6
P.serotina	.7	.7	.3	4.9	0	0	0	0		0	0	0	0		
P.taeda	.5	0	.2	2.8	.2	0	.11	7.5		0	0	0	0		
N.sylvatica	.3	0	.2	2.5	0	0	0	0		0	0	0	0		
O.arboreum	.3	0	.2	2.5	0	0	0	0		0	0	0	0		
I.opaca	.2	0	.2	2.2	0	0	0	0		0	0	0	0		
L.styraciflua	.2	0	.2	2.2	0	0	0	0		0	0	0	0		
S.albidum	.2	0	.2	2.2	0	0	0	0		0	0	0	0		
Total	31.8				4.3				86.4	3.5				2.6	89.0

A2-Table 11. Understory composition of Barrens 1. Density, standard error, frequency and importance value. n=10. Species exhibiting all zeroes were sampled in 1989.

9 spp.	1985 (Pre-burn)				1986				1988 20 spp.			
Species	Density (Ind/m2)	SE	Frequency	IV	Density	SE	Frequency	IV	Density	SE	Frequency	IV
G.baccata	6.0	1.4	.7	31.8	28.9	5.0	.8	27.5	32.8	7.5	.90	24.3
K.angustifolia	4.5	1.4	.7	26.9	27.5	10.1	.6	24.5	28.7	14.6	.50	19.2
G.procumbens	1.4	.7	.5	12.5	6.6	5.3	.6	10.9	2.4	1.9	.50	5.8
P.aquilinum	1.0	.9	.3	9.3	1.2	1.1	.3	3.8	4.6	4.6	.30	4.8
V.vaccilans	.5	.5	.2	5.6	.4	0	.1	1.3	4.0	1.9	.50	6.5
G.dumosa	1.0	0	.1	5.3	3.5	3.5	.5	7.8	6.8	5.1	.40	7.0
G.frondosa	.5	0	.1	3.7	3.2	0	.1	3.1	10.9	5.4	.60	10.6
S.glauca	.1	0	.1	2.4	1.6	.3	.6	7.5	3.5	2.5	.50	6.3
I.glabra	.1	0	.1	2.4	.3	.3	.2	2.2	0	0	0	0
S.albidum	0	0	0	0	0	0	0	0	.7	.6	.30	2.9
V.tenellum	0	0	0	0	0	0	0	0	0	0	0	0
C.alnifolia	0	0	0	0	.3	0	.1	1.2	.1	0	.10	1.1
L.mariana	0	0	0	0	0	0	0	0	0	0	0	0
P.palustris	0	0	0	0	0	0	0	0	.1	0	.10	1.1
P.taeda	0	0	0	0	0	0	0	0	.2	.2	.20	1.6
P.serotina	0	0	0	0	.1	0	.1	1.1	.4	0	.10	1.2
A.canadensis	0	0	0	0	.6	0	.1	1.4	1.0	1.0	.20	1.1
A.gigantea	0	0	0	0	.2	0	.1	1.2	0	0	0	0
S.walteri	0	0	0	0	.1	0	.1	1.1	.2	0	.10	1.1
S.rotundifolia	0	0	0	0	0	0	0	0	.2	0	.10	1.1
L.racemosa	0	0	0	0	0	0	0	0	.3	0	.10	1.2
E.hieracifolia	0	0	0	0	0	0	0	0	.5	0	.10	1.3
D.virginiana	0	0	0	0	0	0	0	0	.1	0	.10	1.1
N.sylvatica	0	0	0	0	.1	0	.1	1.1	0	0	0	0
P.melanocarpa	0	0	0	0	.1	0	.1	1.1	0	0	0	0
Q.laevis	0	0	0	0	0	0	0	0	.2	0	.10	1.1
Q.nigra	0	0	0	0	0	0	0	0	0	0	0	0
R.nudiflorum	0	0	0	0	.3	0	.1	1.2	0	0	0	0
V.corymbosum	0	0	0	0	1.2	0	.1	1.8	0	0	0	0
P.polygama	0	0	0	0	0	0	0	0	0	0	0	0
A.rubrum	0	0	0	0	0	0	0	0	0	0	0	0
Total	15.1				76.2				97.7			

A2-Table 11A. Understory composition of Barrens 1. 1989.

22 spp.	1989			
Species	Density (Ind/m2)	SE	Frequency	IV
G.baccata	25.5	6.1	.80	19.2
K.angustifolia	28.2	14.9	.50	17.9
G.procumbens	3.3	2.4	.30	4.1
P.aquilinum	6.2	6.2	.40	6.4
V.vaccilans	4.3	3.7	.40	5.5
G.dumosa	1.5	1.2	.30	3.2
G.frondosa	17.0	7.7	.70	14.1
S.glauca	6.5	4.8	.60	8.1
I.glabra	0	0	0	0
S.albidum	.1	0	.10	1.1
V.tenellum	8.5	8.5	.20	5.8
C.alnifolia	.6	.6	.20	2.1
L.mariana	.9	0	.10	1.4
P.palustris	.2	0	.20	1.9
P.taeda	.2	0	.10	1.1
P.serotina	.1	0	.10	1.1
A.canadensis	.3	0	.10	1.2
A.gigantea	.4	0	.10	1.2
S.walteri	.2	0	.10	1.1
S.rotundifolia	0	0	0	0
L.racemosa	0	0	0	0
E.hieracifolia	0	0	0	0
D.virginiana	0	0	0	0
N.sylvatica	.1	0	.10	1.1
P.melanocarpa	.1	0	.10	1.1
Q.laevis	.2	0	.10	1.1
Q.nigra	.4	0	.10	1.2
R.nudiflorum	0	0	0	0
V.corymbosum	0	0	0	0
P.polygama	0	0	0	0
A.rubrum	0	0	0	0
Total	104.8			

A2-Table 12. Understory composition of Barrens 2. n=6

10 spp.	1986 (Pre-burn)				1988				1989 21 spp.			
Species	Density (Ind/m2)	SE	Frequency	IV	Density	SE	Frequency	IV	Density	SE	Frequency	IV
G.dumosa	9.4	4.7	1.0	21.6	16.2	8.2	.6	13.9	16.0	7.6	.8	10.8
G.procumbens	10.6	5.2	.8	21.3	17.5	10.0	.6	14.6	31.5	21.1	.8	16.1
K.angustifolia	7.0	5.2	.6	14.7	19.8	19.8	.3	12.8	20.0	20.0	.3	8.9
G.frondosa	4.6	2.8	.6	11.6	11.0	11.0	.5	9.8	12.3	12.3	.3	6.3
G.baccata	3.8	3.4	.6	10.6	13.0	6.5	.6	12.3	11.5	2.4	.7	8.2
L.mariana	2.0	1.4	.6	8.3	7.2	6.9	.5	7.9	8.2	8.2	.3	4.9
P.aquilinum	.8	.8	.4	4.9	1.5	1.5	.3	3.6	2.2	2.2	.3	2.8
S.albidum	.4	0	.2	2.4	.7	0	.1	1.8	0	0	0	0
S.glauca	.2	0	.2	2.2	1.0	0	.3	3.3	2.5	2.5	.3	2.9
Q.laevis	.2	0	.2	2.2	0	0	0	0	0	0	0	0
V.tenellum	0	0	0	0	4.5	2.9	.3	5.1	23.7	8.7	1.0	14.4
P.serotina	0	0	0	0	0	0	0	0	1.0	.5	.7	4.6
V.vaccilans	0	0	0	0	0	0	0	0	7.3	0	.2	3.6
A.canadensis	0	0	0	0	4.0	0	.1	3.5	1.5	0	.2	1.6
S.walteri	0	0	0	0	.2	0	.1	1.6	3.5	.2	.2	2.3
P.barbulata	0	0	0	0	.5	0	.1	1.7	.7	.7	.3	2.4
P.polygama	0	0	0	0	.2	0	.1	1.6	0	0	0	0
P.lanuginosum	0	0	0	0	.3	0	.1	1.6	.5	0	.2	1.3
C.nigromarginata	0	0	0	0	1.0	0	.1	2.0	2.2	2.2	.3	2.8
S.rotundifolia	0	0	0	0	.3	0	.1	1.6	.3	0	.2	1.2
R.nudiflorum	0	0	0	0	.2	0	.1	1.6	0	0	0	0
P.taeda	0	0	0	0	0	0	0	0	.2	0	.2	1.2
G.sempervirens	0	0	0	0	0	0	0	0	1.3	0	.2	1.5
I.opaca	0	0	0	0	0	0	0	0	.2	0	.2	1.2
I.glabra	0	0	0	0	0	0	0	0	.2	0	.2	1.2
P.melanocarpa	0.0	0	0	0	0	0	0	0	0	0	0	0
Total	39.0				99.0				146.7			39.0

A2-Table 13. Understory composition of Mesic Area 1. n=12 Species exhibiting all zeroes were sampled in 1989.

15 spp.	1985 (Pre-burn)				1986				1988 35 spp.			
Species	Density (Ind/m2)	SE	Frequency	IV	Density	SE	Frequency	IV	Density	SE	Frequency	IV
V.corymbosum	1.09	.4	.5	14.0	5.4	2.6	.4	10.5	6.3	3.7	.50	5.7
G.frondosa	1.27	.6	.4	13.0	2.2	0	.0	3.5	11.9	5.2	.67	9.6
C.alnifolia	1.27	.9	.3	12.5	4.3	1.5	.6	10.8	6.5	3.2	.58	6.1
P.melanocarpa	1.18	1.4	.3	12.0	.8	.6	.3	3.6	.2	0	.08	.5
I.glabra	.73	.5	.3	9.5	.6	.4	.2	2.8	1.1	.8	.33	2.0
A.gigantea	.73	.5	.3	9.5	.8	.8	.2	3.1	.3	0	.08	.5
P.aquilinum	.45	.3	.2	6.0	1.7	.6	.5	6.8	10.3	4.1	.75	8.9
A.canadensis	.27	.4	.1	4.0	.8	.8	.3	3.6	1.3	1.3	.17	1.5
K.angustifolia	.54	0	.0	4.0	3.3	3.3	.2	6.5	5.7	5.7	.17	3.9
M.virginiana	.18	.2	.1	3.5	.3	0	.0	1.0	1.0	1.0	.25	1.6
S.glauca	.18	.1	.1	3.5	1.3	.4	.5	5.7	4.3	.8	.92	6.4
G.baccata	.27	0	.0	2.5	7.3	4.3	.3	12.5	2.0	2.0	.25	2.2
L.racemosa	.18	0	.0	2.0	.2	0	.0	.8	2.4	.9	.58	3.9
N.syvatica	.09	0	.0	1.5	.3	.3	.1	1.9	.9	.6	.33	1.9
M.repens	.09	0	.0	1.5	.8	.8	.1	2.6	1.3	1.3	.17	1.5
A.rubrum	0	0	0	0	.2	0	.0	.8	6.9	2.3	.83	7.3
G.procumbens	0	0	0	0	2.7	2.4	.4	6.5	2.2	1.4	.50	3.4
P.serotina	0	0	0	0	0	0	0	0	.7	.5	.33	1.8
S.rotundifolia	0	0	0	0	.7	.7	.1	2.4	5.1	3.9	.67	5.8
S.laurifolia	0	0	0	0	0	0	0	0	4.9	4.9	.25	3.8
V.tenellum	0	0	0	0	0	0	0	0	0	0	0	0
H.virginica	0	0	0	0	1.0	.9	.3	4.0	1.2	.8	.33	2.1
E.hieracifolia	0	0	0	0	0	0	0	0	1.5	1.0	.42	2.7
E.capillifolium	0	0	0	0	0	0	0	0	.7	.6	.33	1.8
R.nudiflorum	0	0	0	0	.4	.4	.1	1.9	3.0	3.0	.33	3.1
A.scoparius	0	0	0	0	0	0	0	0	0	0	0	0
C.nigromarginata	0	0	0	0	0	0	0	0	0	0	0	0
E.canadensis	0	0	0	0	0	0	0	0	.8	.8	.25	1.5
G.dumosa	0	0	0	0	.1	0	.0	.6	1.0	1.0	.17	1.3
H.nervosa	0	0	0	0	0	0	0	0	0	0	0	0
I.opaca	0	0	0	0	0	0	0	0	.4	.4	.17	1.0
I.verticillata	0	0	0	0	.6	.3	.2	2.8	.3	0	.08	.5
L.styraciflua	0	0	0	0	0	0	0	0	0	0	0	0
L.mariana	0	0	0	0	.8	.8	.2	3.0	2.0	0	.08	1.5
M.cerifera	0	0	0	0	.2	0	.0	.8	0	0	0	0
O.arboreum	0	0	0	0	0	0	0	0	0	0	0	0
P.americana	0	0	0	0	0	0	0	0	.1	0	.08	.4
P.taeda	0	0	0	0	0	0	0	0	.5	.5	.25	1.4
P.arbutifolia	0	0	0	0	0	0	0	0	.7	.7	.17	1.1
Q.nigra	0	0	0	0	.2	.2	.1	1.8	0	0	0	0
S.albidum	0	0	0	0	0	0	0	0	2.3	2.3	.33	2.7
S.cyperinus	0	0	0	0	0	0	0	0	0	0	0	0
S.walteri	0	0	0	0	0	0	0	0	.2	0	.08	.5
W.virginica	0	0	0	0	.1	0	.0	.6	0	0	0	0
Total	8.5				36.9				90.3			

A2-Table 13A. Understory composition of Mesic Area 1. 1989.

42 spp.	1989			
Species	Density (Ind/m2)	SE	Frequency	IV
V.corymbosum	7.5	2.9	.58	6.4
G.frondosa	9.8	3.1	.58	7.7
C.alnifolia	7.0	3.0	.50	5.8
P.melanocarpa	.7	.6	.25	1.4
I.glabra	.4	.3	.25	1.2
A.gigantea	2.4	2.0	.42	3.0
P.aquilinum	9.0	3.0	.75	7.9
A.canadensis	1.7	1.6	.17	1.6
K.angustifolia	6.8	6.8	.17	4.4
M.virginiana	.3	.3	.17	.9
S.glauca	4.8	1.1	.83	5.9
G.baccata	1.0	1.0	.17	1.3
L.racemosa	2.4	1.6	.33	2.8
N.syvatica	1.5	1.4	.25	1.8
M.repens	.8	.8	.25	1.4
A.rubrum	7.5	2.9	.92	7.8
G.procumbens	5.2	3.9	.58	5.2
P.serotina	1.7	.4	.67	3.6
S.rotundifolia	7.7	4.6	.67	6.8
S.laurifolia	2.9	2.9	.33	3.1
V.tenellum	2.2	2.2	.25	2.2
H.virginica	2.0	1.6	.33	2.6
E.hieracifolia	.6	.6	.25	1.3
E.capillifolium	.4	.4	.17	.9
R.nudiflorum	.9	.9	.25	1.5
A.scoparius	.2	0	.17	.8
C.nigromarginata	.2	0	.08	.4
E.canadensis	.5	.5	.25	1.3
G.dumosa	.5	0	.08	.6
H.nervosa	.2	0	.08	.6
I.opaca	.2	0	.08	.4
I.verticillata	.5	.5	.25	1.3
L.styraciflua	.1	0	.08	.4
L.mariana	.4	0	.08	.5
M.cerifera	0	0	0	0
O.arboreum	.7	0	.17	1.1
P.americana	0	0	0	0
P.taeda	.8	.8	.25	1.4
P.arbutifolia	.1	0	.08	.4
Q.nigra	.2	0	.08	.4
S.albidum	.8	.8	.25	1.5
S.cyperinus	.1	0	.08	.4
S.walteri	.2	0	.08	.4
W.virginica	.1	0	.08	.4
Total	93.0			

A2-Table 14. Understory composition of Mesic Area 2. n=9

16 spp.	1986 (Pre-burn)				1988				1989 29 SPP.			
Species	Density (Ind/m2)	SE	Frequency	IV	Density	SE	Frequency	IV	Density	SE	Frequency	IV
V.corymbosum	2.11	2.1	.2	13.6	1.3	0	.1	3.4	1.8	1.6	.33	5.0
S.glauca	1.00	.4	.5	12.6	1.8	.4	.8	9.5	3.3	.9	.89	11.2
C.alnifolia	1.44	.9	.3	11.8	1.7	.5	.6	7.8	2.3	1.1	.55	7.3
P.aquilinum	1.00	.6	.4	11.1	.8	.8	.2	3.0	1.6	.9	.44	5.4
S.rotundifolia	.67	.2	.4	9.4	2.4	.5	.6	9.3	2.8	1.0	.44	7.3
A.gigantea	.78	.8	.3	8.5	.5	.5	.2	2.6	1.2	1.2	.22	3.4
G.procumbens	1.00	1.0	.2	8.1	2.0	1.5	.4	6.9	.9	.9	.22	2.9
S.albidum	.22	.2	.2	4.2	2.9	1.1	.7	10.9	.4	.3	.33	2.9
R.nudiflorum	.33	0	.1	3.2	4.6	4.6	.2	10.4	4.4	4.4	.22	8.3
A.canadensis	.33	0	.1	3.2	.1	0	.1	.9	.1	0	.11	.9
H.virginica	.33	0	.1	3.2	.3	.3	.2	2.2	0	0	0	0
C.glabra	.11	0	.1	2.1	0	0	0	0	0	0	0	0
I.glabra	.11	0	.1	2.1	0	0	0	0	0	0	0	0
Q.falcata	.11	0	.1	2.1	0	0	0	0	0	0	0	0
V.rotundifolia	.11	0	.1	2.1	.2	0	.1	1.2	0	0	0	0
W.virginica	.33	0	.1	2.1	.2	0	.2	2.0	1.0	1.0	.22	3.1
A.rubrum	0	0	0	0	1.8	.8	.6	8.0	2.3	1.0	.44	6.6
P.taeda	0	0	0	0	.1	0	.1	.9	.7	.4	.44	4.1
G.frondosa	0	0	0	0	.3	0	.1	1.4	2.1	2.1	.22	4.8
S.laurifolia	0	0	0	0	.1	0	.1	.9	1.8	1.8	.22	4.3
V.tenellum	0	0	0	0	.8	.5	.2	3.0	1.3	1.3	.22	3.6
Q.nigra	0	0	0	0	.3	.3	.2	2.2	.4	.4	.22	2.2
D.virginiana	0	0	0	0	0	0	0	0	.1	0	.11	.9
G.baccata	0	0	0	0	.9	0	.1	4.3	.4	0	.11	1.4
G.sempervirens	0	0	0	0	0	0	0	0	.4	.4	.22	2.2
I.opaca	0	0	0	0	.1	0	.1	.9	.2	.2	.22	1.9
K.angustifolia	0	0	0	0	0	0	0	0	.3	0	.11	1.3
L.styraciflua	0	0	0	0	.4	0	.1	1.6	0	0	0	0
L.tulipifera	0	0	0	0	.4	0	.1	1.6	.3	0	.11	1.3
M.repens	0	0	0	0	.1	0	.1	.9	0	0	0	0
M.cerifera	0	0	0	0	.8	.8	.2	3.0	.4	0	.11	1.4
N.sylvatica	0	0	0	0	.3	0	.1	1.4	.1	0	.11	.9
O.cinnamomea	0	0	0	0	.1	0	.1	.9	0	0	0	0
O.arboreum	0	0	0	0	0	0	0	0	1.1	1.1	.22	3.2
P.serotina	0	0	0	0	0	0	0	0	.2	0	.11	1.1
Q.alba	0	0	0	0	.1	0	.1	.9	0	0	0	0
Q.phellos	0	0	0	0	0	0	0	0	.2	0	.11	1.1
R.radicans	0	0	0	0	0	0	0	0	.1	0	.11	.9
Total	10.0				25.6				32.6			

A2-Table 15. Understory composition of the Swamp. n=6
Species exhibiting all zeroes were sampled in 1989.

6 spp.	1985 (Pre-burn)				1986				1988 21 spp.			
Species	Density (Ind/m2)	SE	Frequency	IV	Density	SE	Frequency	IV	Density	SE	Frequency	IV
C.alnifolia	3.0	1.4	.5	42.6	9.2	5.3	1.0	28.6	2.2	1.5	.33	8.0
V.corymbosum	.7	.4	.5	20.1	3.8	2.7	.5	12.7	2.2	1.2	.50	9.6
M.virginiana	.5	.5	.3	13.8	.7	.7	.3	4.5	0	0	0	0
G.procumbens	.5	0	.1	9.5	1.7	1.7	.3	6.6	0	0	0	0
S.rotundifolia	.3	0	.1	7.8	.7	.6	.3	4.5	.2	0	.17	2.0
G.frondosa	.2	0	.1	6.3	0	0	0	0	.3	0	.17	2.4
A.rubrum	0	0	0	0	.5	.3	.3	4.2	8.0	2.5	.67	24.4
P.aquilinum	0	0	0	0	.2	0	.2	2.0	1.7	1.7	.33	6.9
L.racemosa	0	0	0	0	0	0	0	0	1.8	0	.17	5.8
A.canadensis	0	0	0	0	.2	0	.2	2.0	.7	0	.17	3.1
S.laurifolia	0	0	0	0	.2	0	.2	2.0	.2	0	.17	2.0
E.canadensis	0	0	0	0	0	0	0	0	.2	0	.17	2.0
E.capillifolium	0	0	0	0	0	0	0	0	.3	0	.33	3.8
P.serotina	0	0	0	0	0	0	0	0	.3	0	.17	2.4
E.hieracifolia	0	0	0	0	0	0	0	0	.8	.7	.50	6.6
I.verticillata	0	0	0	0	1.5	.8	.7	9.4	0	0	0	0
M.repens	0	0	0	0	1.7	1.7	.3	6.6	.2	0	.17	2.0
H.nervosa	0	0	0	0	0	0	0	0	0	0	0	0
H.virginica	0	0	0	0	0	0	0	0	.8	0	.17	3.5
I.glabra	0	0	0	0	.3	0	.2	2.3	0	0	0	0
I.opaca	0	0	0	0	0	0	0	0	.2	0	.17	2.0
K.angustifolia	0	0	0	0	0	0	0	0	0	0	0	0
R.nudiflorum	0	0	0	0	1.0	0	.2	3.7	.2	0	.17	2.0
P.melanocarpa	0	0	0	0	1.5	0	.2	4.8	0	0	0	0
R.radicans	0	0	0	0	0	0	0	0	0	0	0	0
S.albidum	0	0	0	0	.2	0	.2	2.0	.3	0	.17	2.4
S.cyperinus	0	0	0	0	.3	0	.2	2.3	.2	0	.17	2.0
S.glauca	0	0	0	0	0	0	0	0	1.0	1.0	.33	5.3
S.walteri	0	0	0	0	0	0	0	0	.3	0	.17	2.4
W.virginica	0	0	0	0	.3	0	.2	2.3	0	0	0	0
Total	5.2				23.9				22.0			

A2-Table 15A. Understory composition of the Swamp. 1989.

24 spp.	1989			
Species	Density (Ind/m2)	SE	Frequency	IV
C.alnifolia	4.2	2.7	.33	9.4
V.corymbosum	2.0	1.7	.50	7.4
M.virginiana	0	0	0	0
G.procumbens	.2	0	.17	1.7
S.rotundifolia	.7	.7	.33	3.9
G.frondosa	.7	0	.17	2.5
A.rubrum	8.0	4.7	.50	17.0
P.aquilinum	4.8	4.8	.33	10.5
L.racemosa	2.5	2.5	.33	6.8
A.canadensis	1.8	0	.17	4.4
S.laurifolia	.7	.7	.33	3.9
E.canadensis	1.3	0	.17	3.5
E.capillifolium	.5	.5	.33	3.6
P.serotina	.5	.5	.33	3.6
E.hieracifolia	.2	0	.17	1.7
I.verticillata	0	0	0	0
M.repens	.3	0	.17	2.0
H.nervosa	.2	0	.17	1.7
H.virginica	.7	0	.17	2.5
I.glabra	0	0	0	0
I.opaca	.2	0	.17	1.7
K.angustifolia	.3	0	.17	2.0
R.nudiflorum	0	0	0	0
P.melanocarpa	0	0	0	0
R.radicans	.2	0	.17	1.7
S.albidum	.2	0	.17	1.7
S.cyperinus	.3	0	.17	2.0
S.glauca	.7	0	.17	2.5
S.walteri	.5	0	.17	2.2
W.virginica	0	0	0	0
Total	31.5			

A2-Table 16. Seedling and vegetative sprout densities (with standard errors) by species and habitat type. * = significant difference.

	Seedlings		Sprouts	
Understory	Density (Indiv./m2)	SE	Density	SE
Barrens 1				
S.albidum	.40	.27	.40	.30
S.glauca	2.8	1.4	3.4	3.4
V.vaccilans	.80	.80	3.4	2.3
Mesic 2				
A.rubrum	2.3	.76	.67	.67
C.alnifolia	1.8	.92	2.2	1.2
R.nudiflorum	4.3	3.9	.67	.67
S.albidum	2.1	.84	.89	.89
S.glauca	2.6	1.1	1.1	.56
S.rotundifolia	2.9	1.3	1.0	.33
Mesic 1				
A.rubrum *	8.4	2.9	.17	.17
C.alnifolia *	.25	.25	9.6	3.0
I.glabra *	.25	.13	1.8	.70
L.racemosa *	.17	.17	3.3	1.1
A.canadensis	.58	.43	1.7	.98
I.opaca	.33	.22	.25	.25
I.verticillata	.17	.17	.50	.36
M.virginiana	.33	.26	1.4	.67
M.repens	.42	.42	2.0	1.4
P.arbutifolia	.17	.17	.58	.50
P.melanocarpa	.33	.33	1.8	.86
S.rotundifolia	7.3	3.7	.50	.23
R.nudiflora	.33	.26	2.8	2.0
S.glauca	2.7	.71	3.3	1.4
Swamp 1				
A.rubrum	9.2	5.3	3.2	2.6
M.virginiana	.33	.33	.50	.34
M.repens	1.5	1.1	.50	.50
S.rotundifolia	.50	.50	.83	.40

A2-TABLE 17. Understory composition of the burned, not logged treatment. n = 48. Tree and herbaceous species only.

16 spp.	1988				1989				1991 16 spp.			
Species	Density (Ind/21m2)	SE	Frequency	IV	Density	SE	Frequency	IV	Density	SE	Frequency	IV
Q.laevis	7.1	1.4	.73	33.6	7.2	1.3	.69	27.0	5.1	1.6	.67	24.2
S.albidum	3.7	1.2	.60	21.2	3.3	1.1	.58	15.8	2.3	.8	.52	14.3
D.virginiana	1.9	.4	.56	14.7	1.8	.5	.60	12.1	1.5	.5	.52	12.0
P.taeda	1.7	.5	.58	14.6	3.8	1.0	.71	18.4	3.4	1.3	.63	18.8
Q.nigra	.44	.4	.21	4.6	1.5	.3	.65	12.0	1.8	1.1	.31	9.7
C.nigromarginata	.48	.5	.15	3.8	1.3	1.3	.19	5.6	2.4	2.4	.19	9.5
H.hieracifolia	.15	.1	.06	1.4	0	0	0	0	0	0	0	0
Q.margaretta	.15	.1	.06	1.4	0	0	0	0	.1	.1	.06	1.3
E.ipecacuanhae	.02	0	.02	.4	.08	0	.08	1.2	.04	0	.04	.7
P.lanuginosum	.04	0	.02	.5	.25	.2	.06	1.4	.9	.9	.13	4.5
A.rubrum	0	0	0	0	.04	0	.04	.6	.04	0	.04	.7
A.bracteata	.04	0	.04	.8	.06	0	.04	.7	.06	0	.04	.8
C.bellidifolius	.04	0	.04	.8	.10	.1	.06	1.0	.1	0	.06	1.2
C.pallida	.10	0	.02	.6	.10	0	.02	.5	.08	0	.02	.5
C.stimulosus	.02	0	.02	.4	.04	0	.02	.3	.04	0	.02	.4
C.acaule	0	0	0	0	0	0	0	0	.02	0	.02	.3
E.canadensis	.02	0	.02	.4	.06	0	.02	.4	0	0	0	0
L.canadensis	0	0	0	0	.02	0	.02	.3	0	0	0	0
P.palustris	.04	0	.02	.5	.08	0	.06	1.0	.02	0	.02	.3
Q.falcata	0	0	0	0	.04	0	.04	.6	0	0	0	0
Q.velutina	0	0	0	0	.15	0	.02	.6	0	0	0	0
Total	15.1				20.2				17.7			

A2-Table 18. Understory composition of the burned and logged treatment. n=48. Tree and herbaceous species only.

17 spp.	1988				1989				1991			17 spp.
Species	Density (Ind/21m2)	SE	Frequency	IV	Density	SE	Frequency	IV	Density	SE	Frequency	IV
Q.laevis	11.4	1.4	.85	44.0	12.8	1.8	.83	24.8	10.2	1.6	.77	27.8
S.albidum	3.3	1.6	.46	17.0	6.2	6.2	.42	12.3	4.2	.8	.25	10.2
C.nigromarginata	3.4	0	.02	8.1	17.4	5.5	.25	22.5	16.2	.5	.21	26.0
P.taeda	.48	.5	.23	5.7	1.9	1.3	.46	8.0	1.8	1.3	.35	8.8
Q.nigra	.37	.3	.21	5.1	1.0	.5	.38	6.0	.7	1.1	.27	5.8
D.virginiana	.46	.5	.13	3.6	.5	.5	.17	2.7	.4	2.4	.10	2.5
C.stimulosus	.19	.2	.15	3.4	.4	.3	.21	3.1	.3	0	.17	3.4
P.serotina	.67	.7	.08	3.2	.7	.7	.04	1.3	.9	.1	.08	2.7
E.canadensis	.25	.3	.06	1.8	.8	.8	.27	4.3	.02	0	.02	.4
E.hieracifolia	.17	.2	.08	2.1	1.0	0	.17	3.2	0	.9	0	0
E.ipecacuanhae	.06	.1	.04	1.0	.6	.6	.25	3.9	.7	0	.10	2.9
P.lanuginosum	0	0	0	0	1.2	.6	.15	3.2	.5	0	.17	3.6
A.rubrum	.02	0	.02	.4	.04	0	.04	.6	.04	0	.04	.8
A.scoparius	.31	0	.02	1.1	.8	.5	.10	2.2	.9	0	.10	3.1
C.bellidifolius	.04	0	.02	.5	.02	0	.02	.3	.02	0	.02	.4
C.glabra	.02	0	.02	.4	.02	0	.02	.3	.02	0	.02	.4
E.capillifolium	0	0	0	0	.04	0	.02	.3	0	0	0	0
N.sylvatica	.17	.2	.04	1.2	.02	0	.02	.3	.08	0	.02	.5
O.compressa	0	0	0	0	0	0	0	0	.02	0	.02	.4
P.palustris	.02	0	.02	.4	.02	0	.02	.3	0	0	0	0
Total	21.4				45.4				37.1			

A2-Table 19. Understory composition of the mechanically cleared, logged treatment. n=48. Tree and herbaceous species only.

16 spp.	1988				1989				1991		27 spp.	
Species	Density (Ind/21m2)	SE	Frequency	IV	Density	SE	Frequency	IV	Density	SE	Frequency	IV
Q.laevis	5.8	1.9	.52	33.8	6.1	1.8	.63	17.9	4.0	1.1	.56	13.9
Q.nigra	1.4	.5	.40	14.6	2.4	.6	.56	10.4	1.9	.6	.48	9.4
S.albidum	2.1	1.7	.27	14.1	3.8	2.5	.35	10.7	2.2	1.9	.25	6.8
D.virginiana	1.0	1.0	.15	7.0	.8	.8	.23	4.0	.6	.6	.19	3.4
N.sylvatica	.5	.5	.10	4.3	.5	.5	.08	1.8	.2	.2	.06	1.1
P.polygama	.4	.4	.13	4.3	1.8	1.0	.27	6.3	10.9	5.1	.35	22.2
O.arboreum	.6	.6	.04	3.1	.8	.8	.04	1.9	.5	.5	.04	1.4
I.opaca	.4	.4	.06	3.0	.4	.4	.06	1.6	.5	.5	.08	1.8
P.serotina	.4	.4	.04	2.3	.3	.3	.08	1.4	.06	0	.04	.6
C.bellidifolius	.1	.1	.08	2.3	.2	.2	.12	1.8	.2	.2	.12	1.9
A.rubrum	.3	0	.04	2.2	.7	.7	.06	2.0	.6	.6	.04	1.4
P.taeda	.2	.2	.06	2.1	1.5	.5	.54	8.7	.5	.3	.29	4.7
Q.phellos	.1	.1	.06	1.9	.1	.1	.06	.9	.08	0	.04	.7
P.barbulata	.06	0	.06	1.7	.6	.5	.21	3.3	.7	.7	.23	4.2
P.lanuginosum	.2	0	.04	1.6	1.2	.6	.29	5.3	1.1	.9	.23	4.9
A.scoparius	.06	0	.04	1.2	.4	.3	.19	2.7	.3	.3	.15	2.3
C.nigromarginata	0	0	0	0	4.7	2.3	.15	10.3	5.7	2.1	.12	10.7
C.maculata	0	0	0	0	.04	0	.04	.5	.04	0	.02	.3
C.acaule	0	0	0	0	.02	0	.02	.3	.02	0	.02	.3
E.strictus	0	0	0	0	.06	0	.04	.5	.06	0	.04	.6
E.ipecacuanhae	0	0	0	0	.02	0	.02	.3	.04	0	.02	.3
H.gronovii	0	0	0	0	.02	0	.02	.3	.02	0	.02	.3
I.verna	0	0	0	0	.4	0	.04	1.2	.5	.5	.04	1.3
Q.falcata	0	0	0	0	.04	0	.04	.5	.04	0	.04	.6
Q.velutina	0	0	0	0	.1	0	.08	1.0	.1	.1	.06	1.0
S.odora	0	0	0	0	.3	.3	.12	1.9	.4	.4	.10	2.1
X.caroliniana	0	0	0	0	.3	.3	.08	1.4	.1	.1	.04	.8
Total	13.5				27.5				31.0			

A2-Table 20. Understory composition of the mechanically cleared, not logged treatment. n=48. Tree and herbaceous species only.

15 spp.	1988				1989 24 spp.			
Species	Density (Ind/21m2)	SE	Frequency	IV	Density	SE	Frequency	IV
S.albidum	1.0	.41	.4	25.0	1.2	.56	.44	8.8
Q.nigra	.71	.71	.2	15.0	1.5	.95	.44	9.6
P.polygama	.83	.28	.1	15.0	2.3	2.3	.17	7.5
Q.laevis	.37	.16	.1	9.9	.85	.85	.29	6.1
N.sylvatica	.48	.11	.0	8.2	.73	.73	.10	3.1
P.taeda	.23	.06	.1	6.1	.96	.38	.42	8.0
C.nigromarginata	.25	.11	.0	4.9	8.0	3.4	.44	24.1
O.compressa	.12	.06	.0	4.2	.44	.44	.19	3.6
C.bellidifolius	.12	.06	.0	3.5	.10	.10	.04	.8
C.mariana	.10	0	.0	1.8	.02	0	.02	.3
Q.alba	.08	0	.0	2.0	.06	0	.02	.4
S.odora	.06	0	.0	1.4	3.8	2.0	.42	14.4
A.scoparius	.02	0	.0	.9	.06	.06	.04	.7
E.ipecacuanhae	.02	0	.0	.9	.10	0	.02	.5
I.opaca	.02	0	.0	.9	.12	.06	.08	1.5
P.lanuginosum	0	0	0	0	.10	.10	.04	.8
P.serotina	0	0	0	0	.27	.27	.10	2.0
C.fasciculata	0	0	0	0	1.0	0	.02	2.6
C.maculata	0	0	0	0	.12	0	.04	.9
C.acaule	0	0	0	0	.02	0	.02	.3
H.gronovii	0	0	0	0	.12	0	.06	1.2
Q.falcata	0	0	0	0	.02	0	.02	.3
Q.phellos	0	0	0	0	.02	0	.02	.3
Q.velutina	0	0	0	0	.19	0	.06	1.3
Total	4.5				22.1			

A2-Table 21. Understory composition of the control treatment. n=48. Tree and herbaceous species only.

20 spp.	1988				1989				1991			22 spp.
Species	Density (Ind/21m2)	SE	Frequency	IV	Density	SE	Frequency	IV	Density	SE	Frequency	IV
Q.nigra	1.9	.8	.54	26.0	2.9	.6	.79	16.1	1.9	.5	.67	18.6
C.nigromarginata	1.7	1.2	.15	15.6	7.8	2.5	.44	24.5	5.7	1.7	.35	27.6
Q.laevis	.65	.2	.38	12.9	.5	.2	.35	5.2	.3	.3	.12	3.0
S.albidum	.67	.4	.31	11.7	1.3	.4	.50	8.8	.5	.3	.29	6.9
C.bellidifolius	.54	.5	.10	6.3	.8	.8	.17	3.8	.7	.4	.12	4.7
P.taeda	.21	.2	.17	5.1	.7	.4	.35	5.7	.2	.2	.21	4.1
N.sylvatica	.21	.2	.06	4.4	.1	.1	.06	.8	.1	.1	.04	.9
S.odora	.12	.1	.10	3.2	2.0	.4	.67	12.4	1.0	.6	.33	9.4
C.acaule	.08	0	.08	2.4	.3	.1	.21	2.9	.1	.1	.06	1.3
E.ipecacuanhae	.06	0	.06	1.8	.4	.4	.08	2.0	.4	.1	.08	2.8
A.rubrum	.06	0	.06	1.8	.2	.1	.15	2.0	.2	.2	.10	2.3
E.canadensis	.04	0	.04	1.2	0	0	0	0	0	0	0	0
A.scoparius	.02	0	.02	.6	.1	.1	.06	.9	.1	.1	.08	1.9
I.opaca	.04	0	.04	1.2	.04	0	.04	.5	.04	0	.04	.8
L.styraciflua	.10	0	.02	1.2	.1	.1	.06	.9	.1	.1	.04	1.2
P.polygama	.02	0	.02	.6	.1	.1	.04	.7	.04	0	.04	.8
P.barbulata	.12	.1	.04	1.8	.1	.1	.04	.7	.1	.1	.04	1.1
Q.falcata	.02	0	.02	.6	.3	.3	.12	2.0	.1	0	.06	1.3
Q.phellos	.06	0	.06	1.8	.1	.1	.10	1.5	.1	0	.04	.9
Q.velutina	.04	0	.04	1.2	.04	0	.04	.5	0	0	0	0
P.lanuginosum	0	0	0	0	.4	.4	.12	2.3	.7	.7	.12	4.7
C.maculata	0	0	0	0	1.2	1.2	.12	4.4	.8	.8	.06	4.1
D.virginiana	0	0	0	0	.04	0	.02	.3	0	0	0	0
H.gronovii	0	0	0	0	.04	0	.02	.3	.04	0	.02	.5
M.uniflora	0	0	0	0	0	0	0	0	.04	0	.02	.5
Total	6.7				19.6				13.0			

A2-Table 22. Tree seedfall by species and year.

	1987		1988		1989	
Species	Density (seeds/m2)	SE	Density	SE	Density	SE
P.taeda	.30	.30	4.6	1.8	2.1	.90
P.serotina	1.4	.44	.70	.69	1.8	1.7
P.palustris	1.6	.78	.40	.30	0	0
Q.laevis	0	0	0	0	.10	.10
L.tulipifera	0	0	0	0	.10	.10
Total	3.3	.87	5.7	2.0	4.1	1.7

A2-Table 23. Soil seedbank seedling densities. By species.

	Burned		Unburned	
Species	Density (seedl/.14m2)	SE	Density	SE
C.nigromarginata	.50	.18	3.7	.96
P.lanuginosum	2.3	.69	3.3	.76
E.hieracifolia	1.8	.53	1.5	.51
E.capillifolium	1.3	.16	.83	.23
H.nervosa	.50	.18	.17	.13
Dryopteris spp.	2.3	.90	.50	.26
P.aquilinum	0	0	.33	.26
W.areolata	0	0	.33	.16
Total	8.5	2.1	10.7	1.30

A2-Table 24. Tree species composition. Study 2.

Species	Overstory: Density (Ind/500m2)	Overstory: SE	Overstory: Density (Ind/100m2)	Overstory: Dominance (m2/ha)	Overstory: IV	Sapling: Density	Sapling: SE	Sapling: Density
Burned, Not Logged								
P.palustris	25.0	9.1	5.0	7.0	68.0	13.5	10.6	2.7
P.taeda	7.0	4.0	1.4	2.5	21.4	5.0	3.0	1.0
Q.laevis	3.0	0	.6	.5	6.5	4.5	1.5	.9
Q.nigra	.5	.5	.1	.25	1.9	.5	.5	.1
P.serotina	.5	.5	.1	.32	2.2			
Total	36.0		7.2	10.5		23.5		4.7
Burned and Logged								
P.palustris	26.0	4.0	5.2	7.6	79.6	10.0	1.0	2.0
P.taeda	3.5	1.5	.7	.72	9.1	8.5	2.5	1.7
Q.laevis	3.5	.5	.7	.66	8.8	10.5	5.5	2.1
P.serotina	.5	.5	.1	.32	2.5	.5	.5	.1
Total	33.5		6.7	9.3		29.5		5.9
Mechanically Cleared, Logged								
P.taeda	7.0	3.0	1.4	3.1	46.0	9.0	1.0	1.8
P.palustris	5.0	2.0	1.0	1.2	25.0	1.5	.5	.3
P.serotina	2.0	2.0	.4	1.4	17.3			
Q.laevis	2.0	0	.4	.33	8.7	14.5	5.6	2.9
S.albidum	.5	.5	.1	.18	3.0			
N.sylvatica						2.0	1.0	.4
O.arboreum						1.0	1.0	.2
Total	16.5		3.3	6.14		28.0		5.6
Mechanically Cleared, Not Logged								
P.taeda	12.0	3.0	2.4	4.8	61.2	6.5	5.6	1.3
P.palustris	4.0	2.0	.8	.55	13.4	5.0	2.0	1.0
P.serotina	2.0	0	.5	1.3	14.9			
Q.laevis	2.0	1.0	.4	.83	10.5	16.0	12.1	3.2
Q.nigra						2.5	.5	.5
N.sylvatica						2.0	2.0	.4
Q.alba						1.5	1.5	.3
Total	20.0		4.1	7.5		33.5		6.7
Control								
P.taeda	12.0	3.0	2.4	3.4	47.7	21.0	14.1	4.2
P.palustris	9.5	2.5	1.9	3.3	42.2	8.5	2.5	1.7
Q.laevis	2.0	1.0	.4	.54	7.8	16.0	9.1	3.0
P.serotina	.5	.5	.1	.18	2.3	.5	.5	.1
N.sylvatica						2.0	2.0	.4
Q.margaretta						2.0	2.0	.4
O.arboreum						1.5	1.5	.3
Q.nigra						1.0	1.0	.2
Total	24.0		4.8	7.4		53.5		10.5

A2-TABLE 25. Species List.

Species List	84 spp.	
LICHENS	Asteraceae	Hamamelidaceae
Cladonia spp.	*Carphephorus bellidifolius*	*Liquidambar styraciflua*
FERNS	*Erechtites hieracifolia*	Juglandaceae
Blechnaceae	*Erigeron canadensis*	*Carya glabra*
Woodwardia virginica	*Eupatorium capillifolium*	*C. pallida*
Osmundaceae	*Heterotheca nervosa*	Lauraceae
Osmunda cinnamomea	*Hieracium gronovii*	*Persea borbonia*
Pteridaceae	*Lactuca canadensis*	*Sassafras albidum*
Pteridium aquilinum	*Solidago odora*	Loganiaceae
GYMNOSPERMS	Cactaceae	*Gelsemium sempervirens*
Pinaceae	*Opuntia compressa*	Magnoliaceae
Pinus echinata	Clethraceae	*Liriodendron tulipifera*
P. palustris	*Clethra alnifolia*	*Magnolia virginiana*
P. serotina	Diapensiaceae	Myricaceae
P. taeda	*Pyxidanthera barbulata*	*Myrica cerifera*
ANGIOSPERMS	Ebenaceae	Nyssaceae
MONOCOTS	*Diospyros virginiana*	*Nyssa sylvatica*
Cyperaceae	Ericaceae	Phytolaccaceae
Carex nigromarginata	*Chimaphila maculata*	*Phytolacca americana*
Scirpus cyperinus	*Gaultheria procumbens*	Polygonaceae
Poaceae	*Gaylussacia baccata*	*Polygonella polygama*
Andropogon scoparius	*G. dumosa*	Rosaceae
Arundinaria gigantea	*G. frondosa*	*Amelanchier canadensis*
Erianthus strictus	*Kalmia angustifolia*	*Pyrus arbutifolia*
Panicum lanuginosum	*Leucothoe racemosa*	*P. melanocarpa*
Iridaceae	*Lyonia mariana*	Symplocaceae
Iris verna	*Monotropa uniflora*	*Symplocos tinctoria*
Liliaceae	*Oxydendron arboreum*	Vitaceae
Smilax glauca	*Rhododendron nudiflorum*	*Vitis rotundifolia*
S. laurifolia	*Vaccinium atrococcum*	
S. rotundifolia	*V. corymbosum*	
S. walteri	*V. tenellum*	
Orchidaceae	*V. vaccilans*	
Cypripedium acaule	Euphorbiaceae	
Xyridaceae	*Cnidoscolus stimulosus*	
Xyris caroliniana	*Euphorbia ipecacuanhae*	
DICOTS	Fabaceae	
Aceraceae	*Amphicarpa bracteata*	
Acer rubrum	*Cassia fasciculata*	
Anacardiaceae	*Clitoria mariana*	
Rhus copallina	Fagaceae	
R. radicans	*Quercus alba*	
Aquifoliaceae	*Q. falcata*	
Ilex glabra	*Q. laevis*	
I. opaca	*Q. margaretta*	
I. verticillata	*Q. nigra*	
Aristolochiaceae	*Q. phellos*	
Hexastylis virginica	*Q. velutina*	

AUTOBIOGRAPHICAL STATEMENT

Allen E. Plocher was born in Portsmouth, Virginia. He attended public school in Norfolk, Virginia. He received an A.A.S. degree in Forest Management Technology from D. S. Lancaster Community College in June 1977. In December 1980, he received a B.S. in Biology with specialization in Terrestrial Ecology from Old Dominion University. He received an M.S. in Forestry with emphasis on Forest Ecology and Silviculture from West Virginia University in May 1984.

He has co-authored the following paper:

Plocher, A. and K. Carvell, 1987. Population Dynamics of Rosebay Rhododendron Thickets in the Southern Appalachians. Bull. Torrey Bot. Club 114:121-126.